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PROCEEDINGS OF
THE LINNEAN SOCIETY OF LONDON

148th Session (1935–6) Part 3

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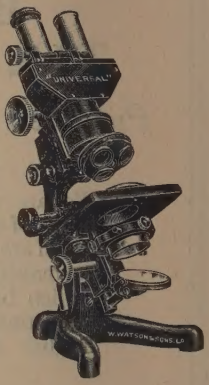

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PROCEEDINGS OF

THE LINNEAN SOCIETY OF LONDON

148th Session (1935–6) Part 3

GENERAL MEETINGS

19 March 1936

Dr. W. T. Calman, C.B., F.R.S., President, in the Chair

The Proceedings of the General Meeting held on Thursday, 5 March 1936, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted :—Theodore George Bentley Osborn, Ben Wells and Tiruvilandur Srinivasa Raghavan.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Paulus Edward Pieris Deraniyagala, Neil Alison Mackintosh and Donald Vanstone.

Preservation of a sea-weed in an air-tight bottle. (Exhibit.) By Miss M. B. Hyde, B.Sc. (Visitor).

The sea-weed (*Sargassum* sp.) was collected by an engineer, Mr. Stanley Tucker, in 1900. It was gathered in the open ocean, the nearest place probably being Cuba. The weed was put into an empty bottle, which was corked and lowered to thirty fathoms, probably about one mile from the coast.

The bottle was afterwards pulled up and the cork covered with pitch and canvas. It was kept for thirty-six years in an ordinary closed cupboard. It remained air-tight apparently until about five years ago, since when the level of the water has fallen two or three inches. The seaweed itself has retained its original colour and seems to be in a state of excellent preservation, although no antiseptic or hardening agent was added.

Dr. G. P. Bidder and Dr. E. M. Delf added some comments.

Lead models of Fungi prepared by Monsieur Jules Lagrange. (Exhibit.) By Mr. John Ramsbottom, O.B.E., Sec.L.S.

The fungus models were prepared by M. Jules Lagrange to aid him in his studies of fungi. There have been many attempts to make models of fungi, the best known in this country being those prepared by James English of Epping, which are still to be seen in some local museums. Wax models of various kinds have been made, but good wax models are far too expensive for any ordinary use.

M. Lagrange's models are made of a special alloy of lead. The process is at present kept secret, but apparently it is possible to begin preliminary preparations in the field and then to delay further work for some days or even months. The specimen itself is destroyed in the process, but the faithfulness of the reproduction is shown by the characteristic markings and fibres on various parts—for example, on the cap of a model of a *Boletus edulis*, where teeth marks can be seen where a squirrel or rabbit has nibbled.

The colouring, though good, is merely to show how well the lead alloy can take it. All the models are from specimens collected in the Department of Creux and M. Lagrange intends to attempt to form a collection which will represent all the species found in France.

The Muséum National d'Histoire Naturelle is very interested in the invention, and it is to Dr. R. Heim, the Assistant Professor in Cryptogamy, that I am indebted for a knowledge of this very cheap and extremely useful method of model-making.

Dr. G. P. Bidder and the President made some remarks on the exhibit.

Demonstration of Allomyces javanicus Kniep. By Mr. F. T. Brooks, F.R.S.

Sexual and asexual cultures of this fungus on oatmeal agar were shown. The motile gametes, germinating zygotes, motile zoospores, and resting spores were also exhibited. The

methods used in cultivating the fungus and in demonstrating the salient features of its life-history were explained.

Dr. F. G. Brieger (Visitor) said that the late Prof. Kniep had pure cultures of *Allomyces javanicus*, and these were used extensively for class work.

Dr. E. J. Butler mentioned that *Allomyces* is not necessarily an inhabitant of stagnant streams or marshy places, as the species he found, *A. arbuscula*, occurred in a concrete gutter in comparatively clean water in motion. It would appear, as he recollected Dr. W. H. Weston also pointed out at Amsterdam last summer, that the asexual stage might reproduce itself almost indefinitely, since he had not found any other stage during a fairly prolonged period of observation of *A. arbuscula*.

Dr. G. P. Bidder also spoke.

A contribution to our knowledge of the aquatic Phycomycetes of Great Britain. By Dr. F. K. Sparrow. (Communicated by F. T. Brooks, M.A., F.R.S., F.L.S.) [Abstract.]

The author investigated the aquatic fungus flora of certain sites at Cambridge and elsewhere during his residence in England during 1932–3, concentrating chiefly on the Chytridiales, Blastocladiales, and Monoblepharidales. Sixty-seven fungi are described in this paper, including three newly proposed genera and several new species of genera already known (e.g. *Pleolpidium Polyphagi*, *Phlyctochytrium laterale*, *Blastocladia glomerata*, *Myzocytium zoopthorum*, and *Pythium perigynosum*). Of the fungi specially studied no less than thirty-nine belong to the Chytridiales, most of which have not previously been recorded in this country. The new genera are represented by *Septolpidium lineare* (parasitic on a diatom), *Rhizidiopsis emmanuelensis* (parasitic on a diatom), and *Scherfelliomyces parasitans* (parasitic on resting cells of *Euglena*), the latter having been originally described by the author under the name of *Scherfellia parasitans*. These new genera belong to the Chytridiales.

Experimental work on the host relationships of *Chytridium lagenaria* is described, it being shown that the fungus from *Rhizoclonium hieroglyphicum* can successfully parasitize species of *Spirogyra* and *Oedogonium*, notwithstanding considerable variation in the rhizoidal systems in the different hosts.

A suggestion is made that *Polyphagus Euglenae* may perhaps comprise two species, one with smooth-walled resting spores, the other with spores having ornamented walls.

The author outlines his methods of collection and examination of these fungi, and emphasizes the richness of the aquatic fungus floras of the sites investigated.

Dr. E. J. Butler said that this valuable and interesting paper showed the wealth of species of this group of fungi that must exist in the streams and ponds. Large numbers also occur in the soil, where the periodical wetting from rain provided sufficient moisture for their propagation. The gaps that still occur in our knowledge of the true relationships of several genera would only be filled as new genera, intermediate between those already known, were discovered, instancing *Septolpidium* as a case in point. The necessity of keeping the uniciliate forms in separate series from the biciliate seems to be becoming more clearly established as time passes.

Mr. D. J. Scourfield said that, with the exception of *Euglena*, no free-swimming algae had been referred to in Dr. Sparrow's paper as the host-plants of Chytrids. It was to be remembered, however, that many motile algae were parasitized by Chytrids, and he had himself seen them on such forms as *Chlamydomonas*, *Chlorogonium*, *Chrysococcus*, and *Peridinium*.

Mr. J. Ramsbottom said that all British mycologists were under an obligation to Dr. Sparrow for the careful work which he had done on a group of fungi which had been much neglected in this country. It was obvious that we had many more species than were described in our books—indeed, far more than Dr. Sparrow had succeeded in finding,—but it needed someone with experience as well as time and application to make the first big haul which would act as an incentive to others.

Dr. Sparrow had fired many with his enthusiasm, and his methods of working were being tried in many different laboratories. The American School has taken the lead in the study of Phycomycetes in recent years, and Dr. Sparrow has done a good service to British mycology during his stay here.

So far as the general question of the evolution and classification of the lower Phycomycetes is concerned, it seems that there must be trends through them leading from Flagellates to the higher Phycomycetes. The number of the cilia of the zoospores, the method of opening of the sporangium, and such characteristics must all be taken into consideration, but we have to bear in mind the probability that there are numerous trends and numerous blind ends. Something like nine lines have been postulated for the lower green algae, and it is not likely that the lower fungi will prove more amenable to theoretical considerations.

Mr. A. D. Cotton pointed out that members of several groups of Phycomycetes could be found, if carefully searched for, in Marine Algae also, especially in the Chlorophyceae and Phaeophyceae, and also he believed in the Florideae.

He had published a paper on marine Pyrenomycetes, but a comprehensive account of the marine Phycomycetes had never been published.

Dr. R. W. Butcher also spoke.

Some general remarks on the Bat-parasites of the family Nycteribiidae. By Dr. Hugh Scott.

A paper by Dr. Scott on Nycteribiidae having been read in title on March 5th *, the writer took the opportunity to place some general remarks before the meeting. After describing briefly the more important anatomical characters of these extraordinary insects, he referred to the behaviour of the living parasites, especially to the observations made on several species of Nycteribiidae on bats in captivity by the late Frederick Muir in the East Indies, by Rodhain and Bequaert in the Belgian Congo (all of which were summarized by Scott in 1917 †), and, more recently, by A. Hase in Venezuela ‡. Hase described in detail the curious positions assumed by the insects under different circumstances, both on and off the body of the host, including the position of the head during the act of sucking the bat's blood and at other times ; also the crater-like excavations made by the parasites in the bat's dense fur, and their curious forward 'swimming' progress through the fur, in contrast to their extremely swift running in the open.

The female parasite normally leaves the body of the host for the purpose of giving birth to the full-grown larva, which immediately adheres to the substratum and transforms into a puparium. The latter phase was illustrated by figures of puparia of one of the two species of Nycteribiidae occurring in Britain, great numbers of these puparia having been found on the ancient roof-timbers during repairs at High Wycombe church in 1934 §.

In many cases a single species of Nycteribiidae infests several species of bats, especially when the latter hang together at rest ; species of bats which lead isolated lives are, on the whole, much freer from these parasites, and those Nycteribiidae which occur on them are usually restricted to one or few host-species. Conversely, one species of bat, or even a single individual, may be infested by several species of the parasites. An example of limited choice of hosts is afforded by the large parasites of the genus *Cyclopodia*, s. str., which occur only on the large frugivorous bats (family Pteropodidae).

* Subsequently published in the *Journal, Zool.*, xxxix, pp. 479–505, 1936.

† *Parasitology*, ix, pp. 593–600, 1917.

‡ *Zeitschr. Parasitenkunde*, iii, pp. 220–257, 1931.

§ Scott, *Entomologist's Monthly Magazine*, lxx, pp. 255–9, 1934.

Nycteribiidae present curious problems in geographical distribution. Many have an exceedingly wide range, e.g. across the entire extent of the Palaearctic Region, or (in another case) across the Old World Tropics from the Belgian Congo to Labuan. Others are much more localized: for instance, the species of *Cyclopodia* in the Oriental and Australian Regions—a succession of species of this genus can be traced from India eastwards and south-eastwards, the males of several forms being externally indistinguishable, while the females have clear differentiating characters. No species common to the Old and New Worlds is known. The recorded New World species number only about thirteen, roughly one-sixth as many as those recorded from the Old World. The New World species belong to a single genus (*Basilia*), to which the writer's paper in the Society's *Journal* is mainly devoted; very few representatives of this genus are known from the Old World.

Dr. Stanley Kemp added some comments.

2 April 1936

Dr. W. T. Calman, C.B., F.R.S., President, in the Chair

The Proceedings of the General Meeting held on Thursday, 19 March 1936, having been circulated, were taken as read and confirmed.

The President read the following letter addressed to him by the Right Hon. Lord Wigram, G.C.B., G.C.V.O., C.S.I., Secretary to the King and Keeper of the Privy Purse:—

Privy Purse Office
Buckingham Palace, S.W.
24th March 1936.

Dear Sir,

I am commanded by The King to inform you that His Majesty has been graciously pleased to grant his Patronage to The Linnean Society of London.

Yours truly,
Wigram,
Keeper of the Privy Purse.

The President,
The Linnean Society of London,
Burlington House,
Piccadilly, W. 1.

The intimation that His Majesty had graciously consented to honour the Society by becoming its Patron was received with acclamation.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted :—Walter Mervyn Carne, Myfanwy Ellis, Bernard William Harrison Coulson, Noel Yvri Sandwith, and Norman Loftus Bor.

Certificates of recommendation of the following candidates for Foreign Membership were read for the first time :—Boris Aleksyevich Fedchenko, Merritt Lyndon Fernald, Paul Pelseneer, Karl Freiherr von Tubeuf, and William Morton Wheeler.

A certificate of recommendation of the following candidate for Associateship was read for the first time :—Maude J. Delap.

The President announced that the Council had resolved unanimously to award the Linnean Gold Medal for 1936 to Professor John Stanley Gardiner, M.A., F.R.S.

In accordance with Chap. X, Sect. VII of the Bye-Laws, the following Fellows were elected, by show of hands, as Auditors of the Treasurer's accounts for 1935–36 :—

Representing the Council :	Dr. J. Hutchinson.
	Mr. D. J. Scourfield, I.S.O.
Representing the Fellows :	Mr. J. R. Norman.
	Prof. W. Neilson Jones.

New British Marsh Orchids.

By Mr. H. W. Pugsley.

[Plate 2]

In January 1935, my paper 'On some Marsh Orchids' was published in Journ. Linn. Soc., Bot. xlix. pp. 553 sq., and the taxonomic arrangement and nomenclature of a part of the group was considerably revised. It was remarked in that paper (p. 572), in drawing attention to the polymorphism of these plants, that in Great Britain they had lately been so intensively studied in the field that perhaps no further distinct forms would be discovered—an observation, it may be thought, to some extent stultified by the publication of my *Orchis majalis* var. *occidentalis* in the same work.

It has now become evident from the explorations of the last two summers that my estimate of this intensive study was unduly optimistic, for with more accurate knowledge and observation at least four additional new forms have been added to our flora.

Two of these new plants are Irish and connected with *O. majalis* Reichb. One of them somewhat resembles var. *occidentalis* Pugsl. in habit and the form of the labellum, but its foliage is normally unspotted and the flowers are of a lighter purple, with the lip conspicuously spotted rather than variegated. In company with Dr. Praeger I met with this plant at Kenmare on 19 June 1934, and at Cloghane two days later; and a day or two subsequently Messrs. Wilmott and Francis Druce noticed it at Dingle. As the material collected by Mr. Wilmott is better than mine and he was able to secure photographs of the plant, it will be dealt with by him in detail.

The second new plant, from County Wicklow, was first noticed in the herbarium of the Dublin Museum, on my return from Kerry, as another form allied to *O. majalis*, and in the spring of 1935 Mr. J. P. Brunker kindly supplied me with good living material from two Wicklow stations. His first set, from Newcastle (18 May), consisted of plants characterized by slender, flexuous stems, 15–30 cm. high, with close sheaths and bearing only four narrow, linear-oblong, obtuse, channelled, somewhat arcuate-recurved leaves, up to 12 cm. long and not exceeding 1·5 cm. in breadth. These leaves are more or less equally spaced on the stem; in some individuals they are marked with small, narrowly oblong, transverse, brown spots; in others they are unspotted. The flower-spikes are moderately dense, up to 6 cm. long, with the lower bracts exceeding the medium purple flowers, especially in the stronger plants. The flowers are rather large, with spotted sepals, and the labellum about 7 mm. long and 10 mm. broad, cuneate-based and somewhat deltoid in outline, having a short middle lobe not projecting beyond the two side-lobes, and readily reflexing laterally. The labellum is variously marked with fine, dark purple, broken lines and specks, sometimes showing an irregular double loop. The spur is nearly cylindrical, as usual in the forms of *O. majalis*. Mr. Brunker's second set is from Ballyman Glen (4 June), and, although more varied, is evidently conspecific with the Newcastle form. The most luxuriant specimens are 35 cm. in height, their leaves marked with a few small spots tending to become transverse, and with slightly larger flowers with the more or less deltoid labellum about 8 mm. by 10 mm. Some examples, less luxuriant, show unspotted leaves, and the central lobe of the labellum

exceeding the side-lobes. One dwarfer plant has distinctly spotted foliage, the spots circular rather than transverse; another shows finely spotted leaves and lighter purple flowers; and yet another is a sub-albino, with pale, unspotted leaves and whitish pink flowers lined with rosy purple. Subject to these variations, all of the plants agree with the Newcastle specimens as described above. In addition to these specimens, Mr. Brunker sent from both localities one or two plants whose intermediate habit and very broad lips indicate hybridity with forms of *O. maculata* L.

These Wicklow orchids (excluding presumed hybrids) are mainly characterized by their slender, flexuous stems, spare, reflexing, lightly spotted and equally spaced foliage, and *majalis*-like flowers with a subdeltoid labellum. They are unlike *O. Traunsteineri* Saut., which I saw in quantity in South Bavaria in 1934, for this has an erect stem, still narrower, flat, acute, and suberect leaves, placed nearer the base of the stem, and always a lax, few-flowered spike. They appear to agree to some extent with the description of *O. latifolius*, race B 1 *brevifolius* in Ascherson and Graebner's Syn. Mitteleur. Fl., Band iii. p. 737, which is founded on *O. latifolia* bb. *brevifolia* Reichb. f. Icon. Fl. Germ. xiii. p. 58. Reichenbach furnishes a very meagre account of his bb. *brevifolia*, and his plate is stated to have been drawn from a dried Swedish specimen of which neither the collector nor the actual locality is known. The figure depicts a plant with three very short leaves near the base of the stem, which is naked above except for two bracts. Ascherson and Graebner's account is more satisfactory than Reichenbach's, and the form intended evidently possesses the habit of *O. Traunsteineri*, with rather broad, reflexed leaves low on the stem and a distinctly short, few-flowered spike. In the British Museum Herbarium there is a narrow-leaved specimen collected in 1882 by G. Nicholson at Kilmacthomas, County Waterford, which, according to the label, was named *O. latifolia* v. *brevifolia* by Reichenbach. This does not resemble the original figure and may possibly be identical with the Wicklow plant. The exsiccata, E. S. Marshall, no. 2305, from Mallaranny, West Mayo, is somewhat similar. But it is clear, in spite of Nicholson's specimen, that the Wicklow plant cannot be referred to the var. *brevifolia* of Reichenbach or of Ascherson and Graebner. Of other named forms the only ones that appear to resemble this plant are some of those described by Klinge from eastern Europe, and included under *O. Traunsteineri* Saut. by Ascherson and Graebner. All of these, however, seem to be distinguished by their narrower, acute foliage.

The Wicklow plant may thus be held to be an undescribed

form, allied most nearly to *O. majalis* Reichb., but differing from the Saxon type in its slenderer habit, sparer, recurved, and less spotted foliage, and lighter purple flowers with a more deltoid and cuneate-based labellum. It is quite different from var. *occidentalis* Pugsl., which is separable from the type by its dwarfer habit, recurved though equally broad and spotted leaves, shorter bracts (rarely exceeding the flowers), and denser, shorter spikes of rather smaller and darker flowers. It may also be readily distinguished from the new Kerry form previously mentioned. Among other described orchids the only one with which it can well be confused is *O. Traunsteineri* Saut., and it has already been pointed out how it differs from the typical species, although resembling to some extent certain eastern forms included with it.

The existence of three distinct, early-flowering Marsh Orchids in Ireland, all allied to *O. majalis*, but each differing from the typical species in several particulars, and withal almost equally distinct from one another, is a curious fact not easily to be explained. They appear to have no analogues in Great Britain. Their points of distinction are not confined to a single organ of the plant, and are clearly of greater import than such differences as exist between the varieties of *O. latifolia* L. admitted in my former paper, and the great majority of varieties in other recent works on the family. On the other hand, they do not appear to merit specific rank. It consequently seems advisable to treat them as subspecies of *O. majalis* Reichb.

Orchis majalis Reichb. var. *occidentalis* Pugsl. in Journ. Linn. Soc., Bot. xlix. p. 586, thus becomes *O. majalis* subsp. *occidentalis* Pugsl., comb. nov., and the new plant from Wicklow is :—

O. majalis Reichb. subsp. *Traunsteinerioides* Pugsl., subsp. nov.

Exsicc. Pugsley no. 529 (Newcastle, Wicklow), type : no. 530.

Tubera dactylis attenuatis longissimis bifida. *Caulis* 10–(15–30)–35 cm. altus, *gracilis*, vix fistulosus, *flexuosus*. *Folia* saepissime 4, ad. 12 cm. longa, 1·5 cm. lata, *erecto-patentia*, ±*arcuato-recurvata*, *lineari-oblonga*, obtusa (supremo excepto), canaliculata, inferne in vaginas arctas paululum angustata, nunc in paginâ superiore *maculis brunneis parvis* ±*transversis notata*, nunc immaculata, in caule subæqualiter conspersa. *Spica* multiflora, *densiuscula*, ad. 6 cm. longa, bracteis purpurascentibus infimis flores paulo superantibus praedita. *Flores majusculi*, normaliter *laete purpurei* ; sepala lateralia purpureo-maculata ; *labellum* 7–8 mm. longum,

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ORCHIS MAJALIS RCHB. SUBSP.
TRAUNSTEINERIOIDES PUGSL.

circa 10 mm. latum, *subdeltoideum* basi cuneatum, planiusculum tandem lateribus reflexum, lobis lateralibus ±triangularibus obtusis vel angulatis, medioque multum angustiore obtuso saepius haud longiore leviter trilobum, maculis lineisque fractis atro-purpureis obscure variegatum ; calcar fere cylindricum ovario paulum brevius.

O. Traunsteinerioides is at present known with certainty only from County Wicklow, but it may occur elsewhere in Ireland. Some specimens from Yorkshire referred to *O. latifolia* var. *eborensis* Godfery are also not unlike it. What this variety really is is still a mystery. It is described by Godfery (Mon. &c. p. 219) as about 12 cm. high, with leaves 14 cm. long and 10 mm. broad, and small flowers like those of *O. incarnata* (*O. latifolia* L.) in size and shape. Specimens collected at Helmsley, however, by the late T. J. Foggitt, are more than double this height, with foliage less than 10 cm. long and much larger flowers ; and with these my Grassington plant agrees. These specimens belong to *O. majalis* Reichb., *sensu lato*, and seem allied to the subspecies *Traunsteinerioides*, but it is desirable to see more material or the living plant *in situ* before determining their exact relationship.

Besides these plants of *majalis*-affinity another interesting addition to the British flora is *O. latifolia* L. var. *ochroleuca* (Boll) Pugsl., which was discovered in June last in a fen near Diss, in Norfolk, by Mr. J. E. Lousley. The specimens collected precisely match continental exsiccatae of this handsome variety and Nelson's figure in ' Die Orchideen Deutschlands '. In the same month Mr. Brunker sent from County Wicklow excellent examples of *O. latifolia* var. *cambrica* Pugsl., more luxuriant than the original Welsh specimens and fully 30 cm. high. The purple colour of the flowers of this variety is very similar to that of *O. praetermissa* Dr.—a fact perhaps not sufficiently clear in the original description. During June 1935, I was also enabled to see an abundance of *O. latifolia* L. var. *coccinea* Pugsl. on the burrows at Kenfig and Baglan, in Glamorganshire. On these burrows the flowers are less brilliantly coloured than at the *locus classicus*, but the plants are otherwise typical. In company with Mr. P. M. Hall, I saw excellent *O. latifolia* var. *Gemmana* Pugsl. and *O. pardalina* Pugsl. in marshes in South Hants in June 1934.

EXPLANATION OF PLATE 2.

Orchis majalis Reichb. subsp. *Traunsteinerioides* Pugsl. Natural size, with detached flower ×1·5—from a Wicklow specimen.

New British marsh orchids.

By A. J. Wilmott.

[Plates 3–5]

Marsh Orchids have been a subject of special study by British botanists of the last two generations. Papers dealing with them have from time to time been communicated to this Society, and two years ago Mr. Pugsley published in our Journal an account of the British forms as then known, adding a new one discovered by him in Ireland. It is surprising, therefore, that, after so much study, anything new should be forthcoming, but on each of my last two summer excursions with our Treasurer we met with a marsh orchid so diverse from those described that I pronounced them on the spot to be new.

The first was found on 23 June 1934 in a meadow near Dingle, Kerry. It formed a small colony, all but two plants of which were uniform in various peculiar characters. One of the two which differed slightly showed evidence, in its labellum as well as in its spotted leaves, of being a hybrid with some form of *Orchis maculata* or *O. elodes*; the other differed only in its taller and more slender habit, and is, I think, only a weak ('drawn-up') specimen of the new plant. We searched for similar plants when in the Killarney district a few days later, but without success. Mr. Pugsley, however, collected there what appears to be the same plant, thus confirming the distinctness of the Dingle plant, which I describe as :—

Orchis kerryensis sp. nov.; *tuberibus* crassis profunde 4-palmatifidis; *caule* circa 16–20 cm. alto stricto valido fistuloso; *foliis* 6–8 subcoeruleo-glauco-viridibus immaculatis, basalibus plus minusve reductis inferioribus congestis patule recurvatis superioribus angustioribus summis minoribus; *spica* cylindrica vel subovata densi- et grandiflora florum colore *Dianthi monspessulani* ad instar; *bracteis* anguste lanceolatis floribus brevioribus; *perigonii phyllis* externis lateralibus horizontaliter divergentibus; *labello* lateribus concavis subplano, lamina (circa 8 mm. lata) latiore quam longa sed cum lobo medio fere aeque longo ac lato punctis numerosis subseriatim dispositis intensius coloratis aspersa; *calcare* ex comparatione parva gracile, quam ovario longo multo breviore.

Habitat in Hibernia; holotype in Herb. Mus. Brit. ('Kerry; near Dingle, 23 June 1934, coll. A. J. Wilmott').

Tubers deeply 4-palmatifid, stout. Stem fistular (10–) 16–20 cm. high, stiff erect, stout (except in the taller more slender 'drawn-up' specimen). Leaves about 7; the one or two lowest reduced to mere sheaths followed by a transitional

smallish leaf; the next two fully developed leaves set close together, broad and recurved (c. 6 cm. long and 20 mm. broad); the upper three more erect and less recurved, the upmost suberect; the lowest of these upper three longest (c. 10 cm. long and 10–20 mm. broad, sometimes approximate to the lower two and then broad and recurved, sometimes more distant and then narrower and more erect), the upper one smaller narrower, the upmost sometimes bract-like with contracted apex, but usually foliaceous exceeding the base of the spike; all bluish rather glaucous green and quite unspotted. Spike when well developed 6–9 cm. long and 3·5 cm. broad, at first ovate, later cylindrical, with large pinkish mauve flowers (colour recalling that of *Dianthus monspessulanus* or *Geranium pyrenaicum*). Bracts narrowly lanceolate, apically somewhat contracted (sub-acuminate), shorter than the flowers (rather longer than the ovaries), distally purplish. Outer tepals elliptic-ovate, laterals horizontally divergent (c. 7 mm. long and $2\frac{1}{2}$–$2\frac{3}{4}$ mm. broad), the median a little shorter and connivent with the inner tepals. Labellum nearly flat with concave sides; the lamina (c. 8 mm. broad) broader than long (or including the somewhat exserted middle lobe about as long as broad), transversely sub-oblong-obcordate, slightly crenate or subentire, the median lobe sub-rhombic-orbicular or sometimes more acutely pointed; except at the whitish base pinkish mauve, with numerous brilliant deeper spots which generally almost unite into a definite line about the middle of each side. Spur comparatively slender (c. 7 mm. long and except for the expanded mouth c. 1 mm. broad), much shorter than the long ovary.

Mr. Pugsley would probably place the plant as a subspecies of *O. majalis* Reichb., but I am not sure that the Dresden plant, as figured in that author's 'Icones Criticæ', is thus closely related to any British plant which I have yet seen. At the same time, I cannot place this Kerry plant under any other British species. Certainly its tubers, foliage, spreading wing sepals, and broad flat dotted labellum separate it completely from *O. latifolia* L. sensu Pugsley (*'O. incarnata'* auct. angl.). *O. praetermissa* Druce, differs in habit, foliage colour, flower colour, labellum shape, and marking, and I have never seen any approach in that species to *O. kerryensis*. *O. purpurella* Stephenson sometimes has the same habit, but is very different in colour, labellum shape, and marking. The northern variety of *O. praetermissa*, named by Dr. Druce *pulchella*, but transferred by Mr. Pugsley to *O. purpurella*, differs in the same way as both of these species.

I have not yet seen alive the plant named by Mr. Pugsley *O. majalis* var. *occidentalis*, and these forms are notoriously

difficult to understand from dried specimens, but that is described as having constantly heavily spotted leaves etc., whereas *O. kerryensis* was quite unspotted.

The hybrid mentioned above I name :—

× *Orchis dinglensis*, hybr. nov., quam *O. kerryensi* elatior foliis angustioribus maculatis labello absque punctis cum lineis saturate rubro-purpureis pictis (? *O. elodes* × *kerryensis*).

Habitat cum *O. kerryensi*. Holotypus in Herb. Mus. Brit. (Kerry ; Dingle, coll. A. J. Wilmott).

The leaf spots and the labellum markings indicate a hybrid with some form of Spotted Orchis, but I do not feel completely certain which of the two British species was the parent. The shape of the labellum—broad, flat, slightly crenate, with comparatively small middle lobe—indicates *O. elodes* as the other parent, but the lined labellum is more suggestive of *O. maculata* (*O. Fuchsii*). Probably it was the deeper pink form of *O. elodes* which sometimes has a more lined labellum.

The second new plant was found exactly a year later (23 June 1935) on a hill slope above Loch Maree, West Ross. Only a single small colony was found this time also, but the specimens seen were quite uniform in their extremely peculiar characters, and I am unable to refer them to any western European species. I therefore describe it as :—

Orchis Francis-Drucei, sp. nov., *tuberibus* parvis simplice ovatis ; *caule* gracile c. 11–13 cm. alto, *foliis* 4, quorum infimo ad vaginam fere reducto, explanatis 3 lineari-lanceolatis immaculatis ; *spica* subsecunda laxa pauciflora (floribus 5–8) ; *bracteis* saturate purpureo-suffusis ovariis longioribus floribus brevioribus (infimis quam floribus submajoribus) lanceolatis apice longe cucullato-contractis ; *tepalis* externis lateralibus erectis, cum internis labello excepto saturate rubro-purpureis ; *labello* subdeltoideo-obtriangulari interdum paululum obcordato, lobo medio anguste triangulari longe exserto, labelli superficie candida lineis maculisque saturate rubro-purpureis picta (linea submarginale subcontinuo lineis duobus interioribus in maculis dirumptis) ; *calcare* obtuse conico quam ovario breviore.

Habitat in Scotia ; holotypus in Herb. Mus. Brit. (' West Ross ; slopes above Loch Maree, 23 June 1935, coll. A. J. Wilmott ').

Tubers small, simply ovate (c. 7 × 3·5 mm.). Stem slender, slightly flexuous, 11–13 cm. high. Leaves 4 ; the lowest reduced to a sheath with a narrow green foliaceous apex, the three expanded leaves linear-lanceolate, normally broadest between the base and the middle of the lamina, gradually

narrowed upwards, the lowest c. 35×4–5 mm., the middle one c. 40×4 mm., the upper c. 25–30×3 mm. linear or narrowly linear-lanceolate with long narrow contracted point, but actually with obtuse apex, reaching to about the base of the spike; all light green and unspotted. Spike c. 3–3·5 cm. long, sub-secund, 2·5 cm. broad (from the side c. 1·5 cm. broad), lax, 5–8-flowered. Bracts deeply suffused with purple, longer than the ovaries, normally reaching to about the middle of the flowers, but the lower ones rather larger, 3 (–5)veined (ovate-) lanceolate with long contracted narrow apex. Outer tepals 3-veined, the laterals erect (back to back as in *O. latifolia* (*incarnata*), but not touching), obliquely narrow-lanceolate subacuminate at the apex (c. 8 mm. long and 1·5 mm. broad), the median outer (posticous) less acuminate (apex obtuse—c. 7×2 mm.), the internal lateral tepals obliquely lanceolate (5–6×2 mm.) narrowed above but obtuse; all tepals except the labellum dark rich reddish purple. Labellum subdeltoid-obtriangular, sometimes a little ob-cordate, with a long, projecting, narrowly triangular middle lobe about two-thirds the length of the lamina (c. 6 mm. broad and with the middle lobe c. 7 mm. long); with intense reddish purple markings on a white ground, the outer submarginal line subcontinuous at the sides, but broken up distally and on the middle lobe, the inner two lines broken up completely into short lines and dots. Spur obtusely conical (c. 6 mm. long to $2\frac{1}{4}$ mm. broad), distinctly shorter than the curved ovary.

The slender habit, few narrow leaves, short lax few-flowered spike, and long middle lobe of the labellum are all characters which distinguish *O. Traunsteineri* Saut., and a large number of forms of this species have been enumerated (cf. Klinge 1899; in Act. Hort. Petrop. xvii, 75–88). But all of these forms, even the small var. *lapponica* (Laestad.), retain their floral characteristics and labellum shape (recognisable even in dried specimens). *O. Francis-Drucei* differs in its peculiar labellum, with very long projecting median lobe, and brilliant coloration on a white background. It is also smaller and more delicate than any form of *O. Traunsteineri* described. If it should ultimately prove to be referable to that species as a subspecies, this would constitute a considerable extension of range for *O. Traunsteineri*, since all previous records for Britain are erroneous and refer to small narrow-leaved northern forms of *O. latifolia* (*incarnata*). Although only the one small colony was observed, the new plant cannot be satisfactorily referred to any described species, and until further evidence is forthcoming of its range of variation and affinities, it must be kept apart as a distinct species. In naming it after our Treasurer, who saw it first, I commemorate the large number of successful botanical excursions which we have made together.

EXPLANATION OF THE PLATES.

PLATE 3, A. B, C.—*Orchis kerryensis* Wilmott. A, whole plant, × 2/3 (drawn mainly from the type-plant, but the inflorescence and flowers drawn with the help of the photograph of Plate 2 B). B, C, front and side views of flower, × 2 (as Plate 2 B). D, E, F. *Orchis Francis-Drucei* Wilmott. D, whole plant (type), × 2/3. E, F, flowers, × 2. (Del. Miss B.O. Corfe.)

PLATE 4, A, B.—*Orchis kerryensis* Wilmott, × 2; A is from the type-plant.

PLATE 5.—Four plants of *Orchis Francis-Drucei* Wilmott, × 2; the upper to the right is the type-plant.

Mr. P. M. HALL, after thanking the speakers for their papers and the interesting slides and specimens illustrating them, said that the three forms described appeared to be new in the sense that they were recognisably distinct from any British Marsh Orchid as yet described. As our knowledge of the Marsh Orchids increases, it is becoming clear that there are a number of related, but distinct, forms in this country with very limited distribution. The origin of such local forms is not yet known, but homogeneous populations occur in such circumstances as to suggest that hybridisation is one of the causes. Sometimes a large uniform colony is found with smaller numbers of two presumed parent species whose characters it combines. Here there is not a complete range of variation from one parent to the other: the offspring appears to breed true and behave as a species, but backcrosses with the presumed parents are very scarce—if, indeed, they occur at all. At other times only one other or no other species of Dactylorchid occurs in a colony.

Mr. JOHN S. L. GILMOUR said he was extremely interested in the remarks of Mr. Pugsley and Mr. Wilmott, and there was only one point he would like to bring forward. The palmate orchids are, he thought, a group that would yield very valuable results if examined cytologically and genetically. The interrelationship of the various forms so far recognised is by no means clear and the additional information to be obtained by the above methods would certainly throw considerable light on it. The difficulties of breeding orchids are well known, but, if anyone has the facilities and the time for such work, here is a group that would undoubtedly repay investigation.

Mr. E. J. BEDFORD (Visitor) said that, although he had made a large number of drawings of the Marsh Orchids, some of which were exhibited, he was not an expert in the matter of the determination of the species. He was inclined to think these plants hybridise freely and they appear to vary considerably.

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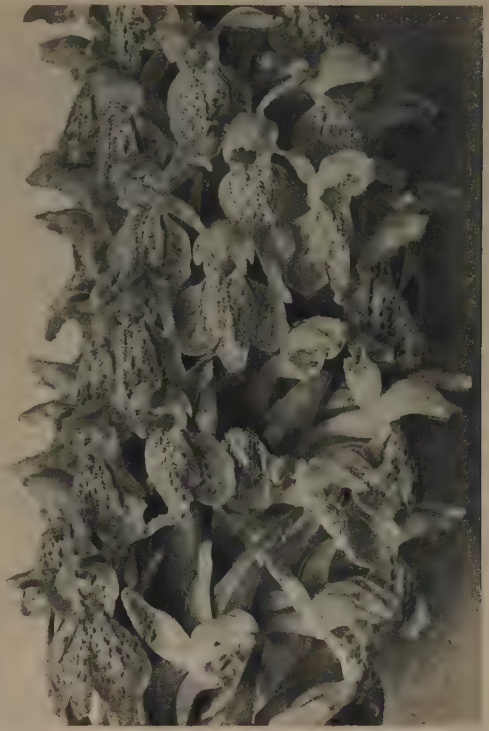
ORCHIS KERRYENSIS WILMOTT &
ORCHIS FRANCIS — DRUCEI WILMOTT.

A



B

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ORCHIS KERRYENSIS WILMOTT.

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ORCHIS FRANCIS – DRUCEI WILMOTT.

A new genus of fossil deer from the Miocene of Africa. By Mr. D. G. MacInnes. (Communicated by Dr. G. P. Bidder, M.A., Sc.D., F.L.S.)

This paper deals with part of a collection of fossil mammals obtained in 1934 on Kiboko Island in the Kavirondo Gulf of Lake Victoria. The material is fragmentary and incomplete, but it is at least sufficient to prove not only the existence of an entirely new form of deer, but also the unsuspected occurrence of a pre-Pleistocene deer in Africa.

This new genus shows certain unusual features, particularly in the form of the antlers, combining some of the characters of known genera, whilst differing in other respects from them all. The beam of the antler was nearly straight throughout its length, bearing numerous short irregular tines. The antlers apparently retained their skin covering permanently, and were therefore not shed annually.

It seems probable that this genus was descended from the *Palaeomeryx* group, but until additional material is available it is impossible to discuss its affinities with any degree of accuracy. The geological horizon of the remains is also uncertain, but, to judge by the other mammalian fossils obtained, the deposit would appear to be of Miocene age.

Attention is drawn to the similarity of the antlers to those depicted in Ancient Egyptian tomb paintings, and also to prehistoric and modern paintings of deer from Abyssinia. Native stories of an animal with branching antlers in the highlands of Abyssinia suggest the possibility that some form of deer is still in existence in that area, and this might even prove to be a descendant of the new fossil genus from Lake Victoria.

Mr. Edgar N. Barclay (Visitor) stated that the antlers, as represented by the drawings shown, were unlike those of any other recent or fossil deer in that they were not dichotomously forked. Dichotomous growth and the homologies between the tines of the antlers of all deer was a theory advanced by Garrod in 1877 and subsequently expanded by Sir Victor Brooke (1878) and Mr. R. I. Pocock (1933). It could be successfully applied to the antlers of all deer with the exception of those under discussion.

Mr. M. A. C. Hinton and Dr. A. T. Hopwood also spoke.

On a new Appendicularian, Bathochordaeus sp., from Bermuda, with a revision of the genus. By Prof. W. Garstang. [Abstract.]

Hitherto only four specimens of this remarkable type of Appendicularian have been recorded, all by the German 'Valdivia' expedition, viz. two veritable giants, 3 ins. long,

from the South Atlantic, the types of *Bathochordaeus charon* Chun (*Aus den Tiefen des Weltmeeres*, 1903, pp. 554–6), and two smaller specimens, <20 mm. long, subsequently found in collections from the Indian Ocean, which were referred to the same species as young specimens by Lohmann (first in Lohmann u. Bückman, *Deutsche Südpolar-Expedition*, xviii, Zool. x, 1926, pp. 109–112; later in his 'Valdivia' report, 1935).

Two specimens were found by me in excellent condition in plankton from about 100 fms. depth at Bermuda in March 1935. They agree in size with the larger of Lohmann's specimens from the Indian Ocean, but differ in details of structure both from these specimens and from Chun's type, especially in their possession of well-developed gill-pouches of cylindrical, not obconical, shape, and of a typical pair of Fol's oikoplasts, each containing 8 giant-cells, in front of the apparatus described by Lohmann in the Indian Ocean specimens. The oesophagus is normal, and lacks the 'crop-like' enlargement of Chun's *charon*. In all other respects the Bermuda specimens agree closely with both Chun's and Lohmann's descriptions of *Bathochordaeus*.

When additional specimens of Chun's type come to hand, I think it will be found that both the oikoplastic epithelium and the form of the gill-pouches and oesophagus are in reality less abnormal than the original descriptions have represented, and the same remark applies, *mutatis mutandis*, to Lohmann's account of the oikothelium of the Indian Ocean specimens.

In the meantime, I propose to distinguish the Bermuda specimens, as well as Lohmann's Indian Ocean specimens, as separate species.

Dr. A. B. Hastings congratulated Prof. Garstang and asked whether *Bathochordaeus* had proved to be a deep-water form.

Dr. Kemp expressed the opinion that *Bathochordaeus* must be an extremely rare species, living when adult at very great depths, for it seemed unlikely that so large an animal would be overlooked. The 'Discovery II' was shortly making a traverse of the Indian ocean in 32° S., using large deep-water nets, and it was to be hoped that further specimens of this remarkable Appendicularian would be obtained.

The President added some comments.

In reply to Dr. Hastings, Prof. Garstang admitted that the original 'Valdivia' specimens were probably fished from much greater depths than the Bermuda specimens, having been taken in vertical hauls from 2000–0 metres. The Bermuda specimens were both immature, and, like the young stages of deep-sea Crustacea and other groups, probably lived nearer the surface than the adults.

23 April 1936

Dr. W. T. Calman, C.B., F.R.S., President,
in the Chair

The Proceedings of the General Meeting held on Thursday, 2 April 1936, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Foreign Membership were read for the second time :—Boris Aleksyevich Fedchenko, Merritt Lyndon Fernald, Paul Pelseneer, Karl Freiherr von Tubeuf, and William Morton Wheeler.

A certificate of recommendation of the following candidate for Associateship was read for the second time :—Maude J. Delap.

After some introductory remarks by the President, Captain F. Kingdon Ward delivered the Hooker Lecture.

THE HOOKER LECTURE

A SKETCH OF THE VEGETATION AND GEOGRAPHY OF TIBET.

By F. Kingdon Ward, B.A. (Cantab.),
F.R.G.S. (Founder's Medal), F.L.S.

[Plates 6–9 and a Map]

Introduction.

Sir Joseph Hooker, in his sketch of the Flora of British India, remarks that 'in a large sense there is no Indian flora proper', meaning that there is no family of plants peculiar to India, and that even endemic genera are rare. In short, India received its flora from the surrounding regions; and Hooker and Thomson, in their Introductory Essay to the Flora Indica, recognized seven distinct elements including an African and an Australian element. The fact that Peninsular India has been land since Silurian time is rather an argument against its developing a peculiar flora; any

family or genera it developed has had ample time to spread to adjacent lands, never very far distant. What is true of India is even more true of Tibet. Peninsular India has been land since the earliest times; but until the end of the Eocene period Tibet and the Himalaya lay beneath the great Eurasian sea called the Tethys. Still less then is there a true Tibetan flora, since no flora could have existed until well on in the Tertiary period; and this flora must have been derived from adjacent regions.

It is becoming increasingly clear, however, that Tibet was completely sterilized during the Pleistocene ice age. An ice sheet formed a continuous barrier from north-west, along the Himalaya to south-east, completely severing the southern peninsulas from the interior of Asia, which was a desert. The present Tibetan flora must therefore have entered the country after the retreat of the ice—that is, in Pleistocene times—and by existing routes. It is not difficult to see whence the various elements—eastern Asiatic, Indo-Malayan, European, Mediterranean, and northern—arrived, nor how they came into the country.

I will briefly outline the history of botanical exploration in Tibet. In 1848–49, Hooker was exploring the Sikkim Himalaya, right to the Tibetan frontier. Thus except for Griffith, who in 1836–37 visited the Mishmi Hills and Bhutan, he was the first to make known to the world the astonishing richness of the eastern Himalayan flora. At a later period, Augustin Henry and the French Catholic priests were collecting in the interior of China, following earlier workers in the coastal region. Gradually the vast floral wealth of China was being revealed. It was Hooker who subsequently recognized the close affinity between the eastern Himalayan and western Chinese floras. Nevertheless, during the present century geographical botanists have laid more emphasis on the *differences* between the Sikkim flora and that of western China than upon their resemblances.

Both regions had been intensively explored. The first by Hooker himself, followed by such an eminent botanist as Wright Smith, the second principally by E. H. Wilson, George Forrest, and Handel-Mazzetti. After Wright Smith in Sikkim, no further serious botanical exploration was done in the eastern Himalaya until the cold weather of 1912, when Burkill visited the Dihang valley. Fettered by the restrictions inevitable on a punitive expedition amongst savage tribes, he was unable to penetrate deeply into the hills; but the comprehensive account he wrote of the botany of the Abor expedition whetted the appetite of all Indian botanists.

Finally, in 1931–34, Dr. N. L. Bor, I.F.S., did some fine pioneer work in the Assam Himalaya east of Bhutan, where

he reached an altitude of 10,000 feet, discovered many new species, and extended the known range of others.

All these explorations, however, were on the southern slopes of the Himalaya, not in Tibet itself.

Up to 1904, Lhasa was still the 'forbidden city' and the goal of explorers. Foiled in their attempts to reach it from India over the Himalaya, they turned their attention to central Asia, and, crossing the deserts, approached Lhasa from the north. They found few plants on the plateau, and collected all they saw. Thus western, central, and northern Tibet were the first, and for long the only explored parts of the country, which was well known to be a cold desert. As the trans-Tibetan explorers, still unable to reach Lhasa, approached China, they began to record the presence of trees and even forest, pastures, and thickets.

Thus it was gradually borne in on thoughtful men that between the dense jungles south of the Himalaya and the interior desert there existed a considerable and varied flora. It was no abrupt transition from the rain forest of the eastern Himalaya to the central Tibetan desert. There was a wide intermediate region with graduated rainfall, temperate climate, and mesophytic type of vegetation.

Still, there seemed no prospect of reaching this unknown land from the south by the shortest route: apart from the physical obstacles, a screen of hostile tribes inhabiting the Himalayan foothills proved an effective barrier. Finally, in 1904 the British Mission to Lhasa paved the way for approach from the north-west, and confirmed the earlier reports. The last doubt vanished. From Lhasa eastwards, Tibet, far from being a desert, boasted a considerable flora. Here then was a virgin country. The gap between Sikkim and the Chinese frontier is 500 miles wide. If we assume a depth of 200 miles, reaching back from the plains well into eastern Tibet, the total area is 100,000 square miles, comprising the whole of the river gorge region of Tibet. This region consists of converging or parallel ranges of mountains crowned by peaks 25,000 feet high, and pierced by river gorges 10,000 feet deep. This physical diversity is accompanied by a corresponding diversity of climate and vegetation; and of this country nothing was known. On the Indian side the eastern Himalaya presents one of the most constantly moist regions in the world, and is covered with dense forest. Contrast this with the cold dry interior desert of Tibet. But between these extremes there is an infinite gradation.

The intermediate region of south-eastern Tibet has furnished proof of Hooker's contention that the Himalayan and western Chinese floras have much in common. Geographical botanists, of whom Hooker was one of the greatest, are

agreed that climate plays the most important part in the classification of plant communities, since it controls the life forms; and in Tibet we shall find many striking examples of the truth of this statement. This then is the country towards which Hooker more than once directed our attention. As I have been fortunate enough to make three extensive journeys north of the main Himalayan range (the last and longest in 1935), in addition to several journeys on the southern slopes, while seeking a way through to the plateau country, and yet other journeys in western China, I propose to devote this lecture to a brief sketch of the vegetation of Tibet.

In the 'Journal of the Linnean Society (Botany)', vol. l. no. 333, I gave a general account of the botany of Tibet in relation to the physical features of the country, pointing out how it is correlated with the three primary divisions of the gradually disintegrating plateau, each of which is characterized by a particular formation. I showed that the Great Himalayan range does not end at the Tsangpo gorge *, but continues in a general south-easterly direction into China; although this extension across the much older Burma arc has been obscured in recent time by ice action, the net result being to produce an illusion of meridional ranges beyond the Tsangpo. Finally, I emphasized the unity of the Tibetan flora as a whole, and dissociated it from that of the Central Asian depression; thus paving the way for the suggestion that the Tibetan, Himalayan, and western Chinese floras really comprise a phytogeographical unit or botanical region (Sino-Himalaya). This conception necessarily implies that the Himalayan flora, previously regarded as an outlying extension of the eastern Asiatic region, renounces its older allegiance, and cleaves to the new; thereby rounding off Sino-Himalaya to the south. In the paper referred to, however, I dealt with the *flora*; I here deal mainly with the *vegetation*.

A New Journey: Route.—In 1935 I made an extensive journey through the unknown regions lying to the north of the Assam Himalaya between the meridians of 92° and 95° east longitude—a part of Tibet which is well covered with vegetation. Starting from Tezpur on the Brahmaputra I traversed the foot hills of the Assam Himalaya west of the Bhareli river and east of Bhutan, comprising part of the Balipara Frontier Tract.

* The Assam–Burma ranges (Arakan Yoma), which are geologically continuous with the Great Himalayan range, I regard, on biological grounds, as a minor divergence of the main range. This also was the view on geological grounds of the late Professor J. W. Gregory. It is not, however, the generally accepted view amongst geographers.

I travelled leisurely while awaiting a permit to cross the frontier ; but so rich is the flora that I was unable to collect more than a tithe of it. Crossing the high Sela range, which forms the *de jure* frontier between Assam and Tibet, I reached the Tibetan province of Mönyul, which, lying to the south of the main Himalayan range, is well forested. I had indeed crossed a corner of Mönyul in February 1925 ; but the country being then under snow I could not obtain more than a superficial idea of the vegetation. Captain G. Sherriff and Mr. F. Ludlow had travelled and collected in Mönyul in 1934 partly over the same ground. Continuing my journey northwards, I crossed the Great Himalayan range by two passes, the Tulung La and the Pen La, both over 17,000 feet high, and reached the outer plateau of Tibet at the sources of the Subansiri river. Passing in turn through the districts of Chayul, Charme, and Tsari, and crossing two more high ranges, I reached the Tsangpo in longitude 94° east. Thence I turned eastwards down the great valley through the province of Kongbo, and at the end of July reached Tongkyuk in the wetter Po country. I spent August exploring the forests of this stupendous mountain and gorge region, eventually joining the Lhasa–China road at Gyamda. Finally, turning south again, I traversed the unexplored mountains between the Lhasa–China road and the Tsangpo along the 93rd meridian, crossed the province of Takpo, and late in September rejoined my outward route at Chayul Dzong. Continuing southwards, I recrossed the Great Himalayan range early in October and, following a somewhat different route over the Sela range from that of the outward journey, reached the Balipara Frontier Tract once more. Thence ten days' marching brought me to the Bhareli river, and to Tezpur at the beginning of November.

During the six months I was in Tibet, I covered about fifteen hundred miles, mostly on foot, through some of the most fertile parts of the country.

I have already described the threefold nature of the Tibetan plateau dividing it into :—

(1) The interior plateau with internal drainage.

(2) The outer plateau comprising the headwaters of the outward flowing rivers.

(3) The river gorge region or dissected plateau, where those rivers are forcing their way through the boundary ranges of the plateau. These gorges clearly show two cycles of erosion, (i.) by ice, (ii.) by water. Here then I shall give a more detailed analysis of the Tibetan vegetation. Broadly, the interior plateau is characterized by a tundra climax,

the outer plateau by an alpine climax, and the river gorge region by a forest climax *.

Any classification of the vegetation of Tibet must take cognisance of the fundamental fact that Tibet is a plateau in process of degradation, and that three successive stages of degradation can be recognized. The correlation of the primary vegetational units with these physiographical divisions, though not, of course, exact, is striking. Hence the vegetation shows a gradually increasing complexity from tundra to scrub or grassland and from scrub or grassland to forest. As regards the interior plateau, the climax formation—tundra—comprises only a single association, that of an open, cold, xerophytic herbaceous community. I have previously given a complete list of the flora, and nothing more need be said about this region at present.

The outer plateau being the link between two extreme climax formations, the desert interior plateau (tundra climax) and the luxuriant river gorge region (forest climax), is necessarily related to both. The climate is intermediate, the vegetation to some extent transitional (ecotone). But the outer plateau has also recognizable climax formations of its own, which I have called alpine climaxes. Two alpine climax formations occur here, an alpine scrub climax in the valleys and an alpine herbaceous climax on the ranges.

If we follow one of the great river valleys, such as the Tsangpo valley, eastwards from the outer plateau to the head of the great gorge, the gradual change of vegetation is apparent. It is hard to say where the tundra of the plateau ends and the forest climax of the river country begins. Here there is no true alpine climax; the transition is through xerophytic thorn scrub.

On the other hand, when crossing a rain screen like the eastern Himalaya the transition from forest to an herbaceous alpine climax of xerophytic type is abrupt: e.g. on the two sides of the Tang La, near Phari, on the main trade route between Sikkim and Lhasa. I found the same abrupt transition from forest to alpine scrub when crossing the Tulung La over the Assam Himalaya. Here there are even differences in the alpine flora on either side of the great snow range. In the earlier paper referred to, however, I made no attempt to define the limits of the outer plateau, where it passes into

* Throughout this paper I have followed as closely as possible the nomenclature of the American ecologist F. E. Clements, as do most British ecologists. Clements, however, includes alpine regions in the tundra climax, partly no doubt for the sake of simplicity. I prefer to distinguish between them, owing to the divergence between the cold desert and true alpine Tibetan types, even though the life-form may be somewhat similar in both. The true tundra is a particularly stabilized area, the alpine region a particularly dynamic one.

the river gorge region. Nature abhors an enclosed space as much as an empty one; yet it is obviously convenient to set bounds, even though arbitrary, to well-defined units of vegetation. On its northern and western borders, as we have seen, the outer plateau of Tibet is indistinguishable physiographically from the 'northern plain' (Chang Tang); nor is there any change in the scattered vegetation which will enable us to draw a dividing line. Yet a definite water parting exists; somewhere the water begins to drain outwards, and there the outer plateau (from the physiographical point of view) begins.

Thus the tundra vegetation does not end at the water parting between interior and outer plateaux, but extends some distance into the outer plateau. Much of western Tibet, though geographically part of the outer plateau, averages 16,000 feet in height and supports only tundra vegetation similar to that of the interior plateau *. In other words, the Tibet lake-basin (interior plateau) does not coincide with the Tibet plateau: the lake basin is only a part of the whole.

The sources of the Indus, Sutlej, Brahmaputra, Salween, Mekong, and Yangtze all lie within the high plateau characterized by tundra climax, and from a purely ecological point of view this area should be classed with the lake-basin region or interior plateau. It is convenient to subdivide Tibet physiographically in accordance with the stages in the degradation of the original plateau; but rigid correspondence between vegetation and surface features cannot be expected. I have endeavoured to show how, on the whole, the vegetation conforms to this triple division. But only a general indication can be given of where one region passes into another whether physiographically or botanically. However, there *is* a sharp physiographical break between the valleys of the outer plateau and the gorges further east with which they are continuous—that is to say, between the outer plateau and the river gorge region. The plateau valleys are entirely water-worn. The river gorge region marks the limit of the southern Tibetan ice cap: the true river gorges were all ice-worn before they were water-worn. The forest region of Tibet coincides closely with the ice-belt.

Although the lake basin of Tibet (which at that time must have been much larger than it is to-day) may formerly have had a moister climate, there is no sign of ice action on the interior plateau. That glaciers, which have since disappeared,

* In their 'Introductory Essay to the Flora Indica', published in 1855, Hooker and Thomson include much of the north-western Himalaya in 'Tibet', whereas in his 'Sketch of the Flora of British India', published in 1904, Hooker puts these regions in their correct place, forming part of his Western Himalayan province (i.e. India).

descended the northern slopes of the Himalaya and interior ranges of Tibet is undeniable; but it is certain that, west of the 93rd meridian, they did not descend far. They must always have been small glaciers.

The river gorge region begins where natural tree growth begins. Thus, in the Tsangpo valley the first scattered trees appear east of the 93rd meridian. Westwards the valley is too dry to support tree growth, and the climax formation is thorn scrub. There may be a thin belt of forest high up on the flanks of the ranges, or in the ravines, but the climate is only exceptionally and accidentally a forest climate, and such forest as exists may be called post-climax. Owing to the fierce winds which blow through the valley, and to the large amount of sand, a xerophytic sub-climax of grasses and herbaceous plants covers much of the ground. Wind is here the limiting factor. Conversely, further west it is only in the bottoms of the valleys, along the streams, that trees grow. Here water is the limiting factor.

In the Yigrong gorge, explored in 1935, thick forest extends as far west as the 93rd meridian, so rapidly is the river gorge climate biting into the outer plateau.

On the other hand, the Salween valley north-east of Nagong and for some distance southwards (lat. 30° N., long. 97° 30′ E.), though 5,000 feet deep, must be regarded merely as a profound trough in the plateau, and not as part of the river gorge country, since it is arid and entirely unforested *. Nor is there any indication of ice action. This is in harmony with the view expressed as to the extension of the Himalayan rain screen beyond the Tsangpo, since the Salween does not begin to cut its gorge through the boundary range until some distance further south.

It will be convenient to give here a list of the *probable* climax formations in Tibet. Future explorers will no doubt introduce modifications :—

Climax.	Locality.
Tundra climax.	Interior Plateau (Tibet Lake Basin).
	Outer Plateau, adjacent. Tsaidam, Ladak, Little Tibet, sources of all the great rivers.
Alpine climaxes.	
Alpine Grassland Formation.	N.E. Tibet, E. Tibet, Chamdo, Markham Dzong.
Alpine Gravel Formation.	South-Central Tibet, Lhasa, Gyantse, Shigatse.

* In a few favoured places, isolated patches of *Picea lichiangensis* occur at 13,000 and 14,000 feet, within the Salween gorge, e.g. above Puti. This is a post-climax community. (See 'The Himalaya East of the Tsangpo', *Geographical Journal*, November 1934.)

Climax.	Locality.
Alpine climaxes (cont.).	
Alpine Thorn Scrub.	South-Central Tibet, Tsangpo valley, Salween valley, Mekong valley, Subansiri headwaters.
Alpine Tundra Formation.	Great ranges of Tibet, 15,000–18,000 feet.
Alpine Shrub Fromation (*Betula*, *Acer*, *Rhododendron*).	South-Eastern Tibet, Zayul, 12,000–13,000 ft. Southern slopes of the rain screen and gorges.
Woodland Climax.	
Betula–Quercus Formation.	Upper Gyamda valley; Tsangpo valley above the gorge; sub-alpine valleys of Charme and Chayul. (Sources of the Subansiri.)
Forest Climaxes: 'Wet' Forest.	
Deciduous Type—*Acer–Magnolia* Formation.	Zayul and S.E. Tibet generally: Tsangpo gorge: Po region, 6,000–8,000 feet.
Semi-deciduous Type—*Quercus–Rhododendron* Formation.	Tsangpo gorge: Yigrong gorge, 7,000–9,000 feet.
Evergreen Type—*Tsuga–Rhododendron* Formation.	Upper Zayul, Mönyul, Pemako, 8,000–10,000 feet.
Sub-Alpine Type—*Abies–Juniperus* formation.	Tsari, Eastern Tibet, 10.000–12,000 feet.
Abies–Picea Formation.	Monyul, Nagong: Kongbo, Zayul, Tsari, Pome, and S.E. Tibet generally.
Forest Climaxes: 'Dry' Forest.	
Sub-Alpine Type—*Picea–Betula* Formation.	Nagong, 12,000–13,000 feet.
Montane Type—*Pinus–Quercus* Formation.	Lower Zayul *: Mönyul.
Evergreen Type—Mixed Pine Forest Formation.	Yigrong gorge, Tsangpo gorge.

Perhaps not all of the above are true climax formations; one or two may be associations within the climax, e.g. the mixed Pine forest of the Yigrong might perhaps more accurately be included in the *Tsuga–Rhododendron* formation, though the latter in its pure state needs a much wetter climate than the former. But in a first description of a country so little known as Tibet it seems more convenient to analyse the vegetation on the basis of possible climax formations. There may be other forest climaxes which I have not seen, but I think that

* Pure stands of *Pinus Khasia* along the valley bottom, between 4,000 and 6,000 feet are encouraged by annual burnings. *P. excelsa* seems to be the dominant species here, as in Mönyul, with *P. Khasia* perhaps subdominant. This latter does not occur in the Assam Himalaya or anywhere west of the Dihang. The dominant Oak in Lower Zayul is *Quercus glauca*, in Mönyul it is *Q. Griffithii* (at 6,000–7,000 feet).

is unlikely. It is impossible at present to say anything about the many plant associations with their dominant species.

The Outer Plateau : General Description.

The country lying between the Assam Himalaya and the Tsangpo, comprising the province of Takpo and the districts of Chayul, Charme, Nye, and others, has little the outward appearance of a plateau. It consists of ranges of mountains composed of sandstones, slates, and shales with occasional limestone, which trend north-eastwards, more or less parallel to the Himalaya, separating deep gorges in which flow the headwater streams of the Subansiri river. It is a dry and for the most part treeless region ; partly covered with thorn scrub, and partly with an alpine tundra herbaceous vegetation. Further west, the valleys are wider and shallower, and the country is more plateau-like with great freshwater lakes and rolling plains, as on the main trade route between India and Lhasa. It is interesting to observe that many species of plants found in the dry north-western Himalaya, but unknown in the eastern Himalaya, are found on the outer plateau *north* of the Assam Himalaya, and even north of the Tsangpo. Hereabouts the Subansiri river pierces the Great Himalayan range, and the scrub climax changes rather abruptly to a forest climax.

The vegetation of the comparatively warm valleys differs from that of the high dividing ranges. It forms distinct altitudinal zones, each of which is a distinct climax formation. The true plateau country, like the shallow valleys eroded in it, is characterized by an open thorn scrub climax, though there are considerable areas of gravel, where hardly any woody plants grow. While mountain ranges and valleys of the outer plateau have each their own climax formation, the vegetation of the valleys themselves is not quite uniform. The vegetation of the deep narrow valleys, where they approach the river gorge region differs from that of the same valleys further west, where they are wider and shallower, and the climate is not only colder, but, what is more important, drier.

The larger vegetation units of the outer plateau may therefore be tabulated as follows :—

(1) Plateau, above 15,000 feet, (indistinguishable from the interior plateau, both physiographically and botanically).	(1) Tundra, as on the interior plateau. (Open cold xerophytic herbaceous climax.)
(2) Plateau valleys.	(2) Thorn scrub climax.
a. 10,000–12,000 feet.	*a. Sophora–Rosa–Berberis* association.
b. 12,000–14,000 feet.	*b. Hippophaë–Lonicera* association.
(3) Plateau ranges.	(3) Alpine tundra climax.

Trees on the outer plateau are exceptional, and are confined to villages, to the banks of streams and irrigation channels, and to river beds *. In the villages, walled enclosures protect groves of Poplar and Willow, forming little oases amidst the arid gravel terraces; but no sooner do the trees reach a certain height than their further upward growth is checked by wind. Such gardens are found so high as 13,000 or 14,000 feet—that is to say, in the cold plateau valleys. All crops are irrigated, and along the channels, which may bring water from several miles distant, grow plants of wide distribution. Many of these owe their presence directly or indirectly to man. But there are also endemic species of restricted distribution, e.g. *Iris* spp. The outer plateau is not only the permanently inhabited portion of Tibet, but the greatest grazing region. In Tibet grazing, much more than agriculture, has interfered with the climax vegetation, and initiated seres. Thus the poor wealth of Tibet is concentrated in the outer plateau and the upper river gorge region.

Trees found on the outer plateau, all of which extend from the upper gorge region, are :—*Hippophaë rhamnoides*, found between 12,000 and 14,000 feet, and as a shrub up to 15,000 feet : *Populus alba* and *P. ciliata*, *Salix amygdalina* and *S. opaca*, these last four found protected up to 14,000 feet : *Ulmus pumila* and *Buddleja tsetangensis* in villages up to 13,000 feet or even 14,000 feet : and *Juniperus incurva* along rivers and streams, and sometimes in villages, protected or not, up to 13,000 feet, and as scrub up to 14,000–15,000 feet, occasionally growing fairly thickly on the dry stony hillsides. In the Tsangpo valley itself *Juniperus* is the first tree to appear by the river. In the ravines *Pinus tabuliformis* and *Quercus Ilex* mark the transition from plateau to river gorge region and forest climax. *Hippophaë* and *Buddleja* sometimes form groves near villages—veteran trees, though stunted, reaching a great bulk.

The Outer Plateau Valleys.

The tree species enumerated, though typical of villages, owe their existence to favourable circumstances, or to man's assistance. They are not characteristic of the outer plateau in general, and where they occur naturally (e.g. *Hippophaë* 'forest' in a river bed) form a post-climax.

The climax community of the outer plateau valleys, warm or cold, is an open growth of thorny or spiky more or less xerophytic shrubs (Scrub climax). A few species, such as

* It is impossible without further study to say which trees, if any, grow irrespective of man's presence on the outer plateau. *Hippophaë rhamnoides* in the gravelly river beds almost certainly does so.

Hippophaë and *Sophora Moorcroftiana* are gregarious; the latter particularly in sandy soil. More commonly the scrub is mixed. At these altitudes and in a climate so arid, aspect is not of paramount importance, and both north and south sides of a valley show much the same vegetation. Alternes are not conspicuous, and, if they occur, are of a minor nature. Thickets of *Berberis*, *Cotoneaster*, *Rosa sericea*, *Leptodermis*, *Spiraea*, *Sophora Moorcroftiana*, *Ceratostigma*, *Ribes*, *Potentilla fruticosa*, *Lonicera*, *Caragana jubata*, and *C. crassispina*, and a few others clothe the dry stony slopes, and little vegetation subsists in between. In gullies and along permanent streams this scrub grows more luxuriantly, and may even form dense thickets. But usually it is open.

Many of the plateau shrubs are common to both warm and cold valleys, that is they have a considerable range of altitude (though sometimes represented by distinct varieties), e.g. *Jasminum*, *Cotoneaster*, *Rosa sericea*. Some have a wider distribution beyond the limits of the outer plateau, but not usually in the same communities.

While it is impossible without intensive and extensive study to describe the various associations of the plateau climax formations, some idea of the vegetation may be gained from the following notes. Units of vegetation are here called communities, a non-committal term, and dominant species are mentioned with reserve. For the same reasons I have said nothing about succession, except for a few minor examples where direct observation was possible; but it is hoped that some foundation for future ecological study has been laid.

Vegetation of the Cold Valleys.

Between about 12,000 and 14,000 feet a few trees are found, and about a dozen species of shrubs, some of which are gregarious. Herbaceous plants of various life forms are numerous, but grasses are comparatively rare, owing, perhaps, to the absence of surface water.

Hippophaë rhamnoides often forms pure stands in the river beds, and individual trees attain a great age. At 14,000 feet a dwarf form, no more than a foot high, sometimes forms dense thickets, e.g. above Lhagu in Nagong, and on the north side of the Pen La, where it is mixed with *Lonicera* sp. *Clematis tangutica* may be associated with *Hippophaë* and sometimes *Jasminum*, but there is no undergrowth.

Juniperus communis, grows gregariously on the hillsides, forming an open community. Probably the woody plant which ascends highest is *Ephedra Gerardiana*, found up to 15,000 feet. Its hard rootstock is buried in the rocky soil, only the green stems appearing above the surface. It is found chiefly on cliffs, and is common throughout the drier

parts of the plateau. Three other notable plants which exhibit much the same life-form, but must be classed as perennial herbs rather than under-shrubs (though they persist for at least twenty years) are *Dicranostigma lactucoides*, *Corydalis*, and a Crucifer. They are all cliff plants, and none of them occur below 13,000 feet. *Diacranostigma lactucoides* especially, like *Ephedra*, has an immense underground woody rootstock. Other characteristic shrubs are *Berberis*, *Salix*, *Ribes*, *Caragana*, several small-leaved species of *Lonicera* resembling *L. syringantha*, *Rosa sericea*, *Buddleja tsetangensis*, and *B. tibetica*. It is difficult sometimes to say where the plateau vegetation ends and the alpine vegetation begins; but we may conveniently take the upper limit of cultivation as the dividing line. In one sense, almost the entire plateau flora is alpine, though in its extreme forms, namely plateau flora and mountain flora, despite many species common to both, are distinct enough. The same is true of the life-forms, and hence of the vegetation. Speaking generally, on the plateau ranges the true alpine climax begins somewhere between 14,000 and 15,000 feet, and extends to 17,000 or 18,000 feet.

Characteristic herbaceous plants of the cold plateau valleys are :—*Incarvillea*, which often forms little colonies amongst shrub growth, and extends downwards into the warmer valleys—at high altitudes it is more widely scattered : *Morina Coulteriana*, also extending downwards : *Dracocephalum tanguticum* : *Meconopsis horridula* in its multiscape form with no central stem : *Iris* sp., a dwarf of turf slopes : *Allium* : *Asparagus* : *Primula tibetica* confined to bogs : *Mazus*.

On cultivated river terraces where soil and water are plentiful, and still more along the water channels a considerable herbaceous flora is found, including several true alpines. Here grow *Primula sikkimensis* * and a gregarious *Iris* (§ *sibirica*), both of which descend into the warm valleys. Other characteristic plants are *Dracocephalum tanguticum*, together with species of *Ranunculus*, *Vicia*, *Mazus*, *Delphinium*, *Thalictrum*, *Euphorbia*, and *Pedicularis*.

Vegetation of the Warm Valleys.

Below 12,000 feet, the climate of the valleys is less harsh, and there is often more water available and for longer periods. Little change in the appearance of the vegetation is observable.

* Discussing the Primulas of the 'Sikkimensis' section in the Botanical Magazine (Tab. 9276) the late Dr. Otto Stapf says : ' None of the three types discussed (i.e. *P. sikkimensis*, *P. pseudo-sikkimensis*, *P. microdonta*) has so far been recorded from Tibet proper '. In 1935 I found *P. sikkimensis* abundant in southern Tibet between the Assam Himalaya and the Tsangpo valley.

The climax is still thorn scrub and the life-forms of the dominants are similar, but new species appear and plant communities are more sharply defined. There is rather more variety. Characteristic plants are :—*Amphicome arguta*, a plant of dry gravel soils ; *Primula sikkimensis* along irrigation channels ; *Didissandra lanuginosa* on cliffs ; *Iris kumaonensis* ; *Androsace*.

The larger valleys, such as the Tsangpo and Salween, each appears to have developed endemic species, which is not surprising, since they are suspected on other grounds to be of different geological ages, or at least to have had very different histories. In the Salween I found *Caryopteris* and *Salweenia Wardii*, both absent from the dry Tsangpo, in spite of its similar climate ; in the Tsangpo valley *Oxytropis sericopetala*, *Onosma Waddellii*, and a species of the curious genus *Pteropyrum**. On the other hand, many species are common to both, e.g. *Oxybaphus himalaicus*, *Wikstroemia*.

The only plant communities to which I need at present draw attention are the sand dune and river gravel xerophyte communities of the Tsangpo valley, and the *Selaginella involvens* family found on the cliffs in every warm dry valley from the Tsangpo to the Yangtze. The sand dune community in particular shows an interesting developmental succession. The first invaders of the dunes are species of grass (*Miscanthus nudipes*), *Oxytropis sericopetala*, *Onosma Waddellii*, *Myosotis* (*Eritrichium* ?). The first shrubs to appear are *Sophora Moorcroftiana* and *Ceratostigma Griffithii* together forming an associes. Much more local is *Caragana tibetica*. The climax formation is thorn scrub. There is also an *Artemisia* ommunity, which grows in pure sand, but only where the sand is flat ; and this is true of other species. It may reasonably be supposed that such plants cannot compete with sand frequently in motion, as it must be on the dunes. Also these species of the flats—which are generally nearer the river—may require a larger or more constant water supply ; or the sand may be mixed with a small proportion of silt. Other characteristic woody plants of the warm plateau valleys are *Plectranthus*, *Wikstroemia*, *Aster*, the scrambling *Jasminum*, *Clematis connata* and *C. tangutica*, *Leptodermis*.

Mountain Ranges of the Outer Plateau.

The vegetation of the great mountain ranges, which cross the plateau in an east–west direction, is much richer in species than that of the valleys, though the same life-forms recur. Although lying north of the Great Himalayan range, the

* *P. Olivieri*, the only Indian species, occurs in Scind.

mountains are better supplied with moisture and less wind-swept than either the valleys or the open plateau. Since they cross the whole of Tibet, these ranges are continuous with those of the river gorge region, where, in fact, the peaks attain their greatest altitude; but the climate becomes much wetter as we travel eastwards along them. As the average humidity increases with increasing altitude from plateau valley to mountain range, the thin xerophytic thorn scrub expands into a definite shrub belt; there may even be a few coniferous trees on the cliffs. Thus the vegetation is divisible into altitudinal zones. In the plateau valleys, no species of *Rhododendron* is found until well into the river gorge region; but on the ranges several bushy or 'dwarf' species appear. The shrub belt, however, is soon replaced by an alpine herbaceous community which extends to 17,000 or 18,000 feet.

Characteristic shrubs of the lowest zone in addition to some of those previously mentioned are:—*Salix*, *Betula cylindrostachya*, sometimes attaining the size of a small tree, *Spiraea laevigata*, *Potentilla fruticosa*, *Rhododendron vellereum* and other species, *Sorbus*, *Prunus*, *Ribes*, *Lonicera*, and a curious small-flowered form of *Clematis montana*.

The shelter afforded by thickets of tall shrubs, and even small Birch trees and *Quercus Ilex*, allows many shade plants to establish themselves—for example, *Thalictrum diffusiflorum* and *Primula pulchelloides*, forming colonies. This might be described as a woodland community, the dominant trees being *Betula cylindrostachya* and *Quercus Ilex*. At the top of the shrub belt, usually between 13,000 and 14,000 feet, the true alpine climax begins. There are two sharply contrasted aspects of the alpine flora, summer (June–July) and autumn (September–October). The summer flora, depending chiefly on melting snow for its water supply, includes species of *Meconopsis* (*M. horridula* and *M. integrifolia*), *Anemone*, *Trollius*, *Primula szechuanica*, *P. sikkimensis*, *Nomocharis nana*, *Stellera Chamaejasme*, *Lagotis*, and others. Somewhat later are *Primula macrocarpa*, *Gentiana amoena*, and *Incarvillea Delavayi*. The autumn aspect includes a notable wealth of Gentians, as *G. Veitchiorum*, *G. sino-ornata*, *G. Georgii*, *Cyananthus lobatus* and *C. Wardii*, species of *Saxifraga*, *Saussurea*, *Cremanthodium*, *Allium*, *Dracocephalum Hemsleyanum*, *Eriophyton Wallichianum*, and others. This flora depends mainly on summer rain for its development, and is at its best when the soil has been warmed up. Above about 14,000 feet on the plateau ranges the smaller plant communities—societies, families, colonies—alternate rather rapidly, and need close study. Gravel, screes, boulder slopes, turf slopes, lake shores, alpine pastures, the sandy flats

of the glaciated valleys, moraines, and cliffs all support different assemblages of plants.

Having regard to the entire alpine region of Tibet, including grassland, gravel, and alpine tundra, Compositae are the most abundant flowering plants met with, both as individuals and species. Immense colonies of a single species, in genera such as *Cremanthodium* or *Aster*, are met with. Species of *Saussurea*, *Lactuca*, *Tanacetum*, and *Crepis* ascend as high as any flowering plants. The next most numerous family is Ranunculaceae, represented by many genera each with several species, often forming large colonies. There is a spring flush of *Anemone*, *Ranunculus*, *Caltha*, *Trollius*, and others, and an autumn flush represented chiefly by *Delphinium* and *Aconitum*.

Gramineae come high up on the list, but not much is known about these at present. Only in the sandy valley of the Tsangpo are grasses numerous. Labiatae are chiefly late summer and autumn flowering. There are a considerable number of genera, but, with the exception of *Salvia*, the number of species is few. A peculiarity about this family is the assumption of a shrubby habit in genera predominantly herbaceous, as an adaption to arid conditions in the valleys.

Rosaceae and Papilionaceae are both represented by ten or more genera, but excepting *Potentilla* in the one and *Astragalus* (or *Oxytropis*) in the other, the genera are small. Large colonies are rarely formed.

Cruciferae are not abundant, though represented by several genera. The same is true of Caryophyllaceae. Both these families, however, send species into the highest regions occupied by flowering plants, e.g. *Arenaria* sp., *Draba alpina*, *Pegaeophyton scapiflorum*. Further eastwards, on the same ranges but in the wetter river gorge region, other families, such as Umbelliferae, become prominent in the high meadow. But even here Compositae never loses its dominating position. Several families are conspicuous by reason of a single dominant genus with numerous species, some at least of which form large colonies; more rarely there is but one species. For example, Scrophulariaceae (*Pedicularis*): Primulaceae (*Primula*, and especially *P. sikkimensis*: also *Androsace*): Saxifragaceae (*Saxifraga*: also *Parnassia*): Liliaceae (*Allium*): Polygonaceae (*Polygonum*): Gentianaceae (*Gentiana*): Campanulaceae (*Cyananthus*): Labiatae (*Phlomis rotata*: *Dracocephalum tanguticum*).

As regards the life-form, the cushion habit is common at high altitudes, but mainly in the drier regions, where it is assumed by a variety of species. On the alpine ranges of the river gorge region, the cushion habit is rare or wanting. On the main range of the Assam Himalaya, *Chionocharis Hookeri* and *Arenaria polytrichoides* form an association, occurring in great

numbers on the gravel slopes at 15,000 feet. Species of *Potentilla*, *Saxifraga*, and other genera also adopt this habit. More common is the rosette habit, seen in *Crepis*, *Lactuca*, *Euphorbia*, and other plants. Certain biennials, which pass their first winter as a crown of leaves come within this category, e.g. *Meconopsis integrifolia*. A few plants form thin mats. These are mostly dwarf shrubs like *Salix*. Bulbous plants are not common on the dry plateau ranges. *Lloydia tibetica*, *Nomocharis nana*, and several species of *Allium* may be mentioned.

As we have seen, the vegetation of the interior plateau is necessarily uniform, and that of the outer plateau only a little less so except in its extremes, e.g. the bottom of a warm valley, as compared with the high alpine range overlooking it. But the vegetation of the river gorge region is extremely diverse.

I have said (*op. cit.*) that the total flora of the interior plateau (including the adjacent parts of the outer plateau—*Scythia deserta*, or desert Tibet) numbers only 53 species; and no genus is represented by more than two species. The outer plateau (*Scythia felix*, or residential Tibet), with a flora amounting to several hundred species, has several comparatively large genera. But it is in the river gorge region (*Scythia horridula*) that the really large families and genera occur.

Taking the whole Tibetan flora, the first ten families, so far as is known at present, are :—Compositae. Ericaceae. Ranunculaceae. Rosaceae. Papilionaceae. Umbelliferae. Gramineae. Cruciferae. Labiatae. Scrophulariaceae. There are at least 50 genera, containing five or more species each. The following are amongst the largest genera :—*Rhododendron*, *Primula*, *Pedicularis*, *Gentiana*, *Cyananthus*, *Meconopsis*, *Allium*, *Saxifraga*, *Lonicera*, *Rubus*, *Anemone*, *Acer*, *Clematis*, *Cotoneaster*, *Berberis*, *Salvia*, *Viburnum*, *Ranunculus*, *Quercus*, *Cremanthodium*, *Aster*, *Saussurea*, *Senecio*, *Iris*, *Aconitum*, *Arisaema*, *Vaccinium*, *Gaultheria*, *Polygonum*, *Corydalis*, *Potentilla*, *Geranium*.

So far I have said nothing about the result of man's interference with the natural vegetation initiating seres. It is now necessary to mention it. Though there is permanent cultivation in the valleys, there is little destruction. The possible agricultural land has been occupied for generations, and is extending very slowly, if at all. There is no burning, for there is insufficient fuel already. The tendency is towards conservation, and man has enriched the oases, both natural and artificial, with trees such as Walnut, Poplar, and Willow. In the fields are found cosmopolitan weeds. Timber used in house construction is brought from afar : a very little is used

for fuel, mainly the underground stems of *Ephedra*, but also Juniper and *Hippophaë*. Yak dung is much used for fuel. Grazing has had far more effect on the natural covering of vegetation than agriculture. The valleys are grazed in winter, the mountains in summer. Millions of sheep, goats, cattle, ponies, mules, and especially yak, have greatly altered the vegetation. Summer camping grounds in the alpine region are sharply distinguished by the luxuriant growth of certain plants, e.g. *Urtica*, *Polygonum*, *Primula sikkimensis*, *P. Roylei*, *Mertensia*, *Rumex*. In June these camps, where the yak are milked and tethered at night, are a sheet of colour due to the closely packed Primulas in bloom. South of the Himalaya in Mönyul (part of the river gorge country, with a forest climate) the dominent *Primula* was a yellow-flowered species, *P. strumosa*, allied to *P. Roylei*.

In Kongbo, north of the Tsangpo, also in the river gorge country, the dominants are first the typical red-flowered form of *P. Roylei*, followed later by *P. sikkimensis*. Such camping grounds afford an interesting study in succession. The same sites are occupied year after year, but abandoned sites are also seen. The yak do not graze down the Primulas, which may owe their presence to some change in the soil which is to their liking or inimical to their competitors. Elsewhere *P. Roylei* does not occur in anything like the same concentration, but is scattered with other plants, either as a woodland species or as a true alpine. However, it grows commonly along paths constantly used by cattle. *P. sikkimensis*, on the other hand, and the very similar meadow *P. alpicola*, forms immense societies in damp meadows within the sub-alpine forest zone. These meadows are, of course, grazing grounds, but not camping grounds. It seems probable, therefore, that where tents have been pitched, the soil is rendered unfit for anything but a rank growth of nettles, docks, *Polygonum*, etc., since these are found also growing in the villages : and that this consocies is followed by the *Primula* consocies. But these grazing communities belong rather to the river gorge region than to the outer plateau.

Transition from Plateau to River Gorge.

The transition from plateau to gorge—from alpine thorn-scrub climax or grassland climax to forest climax—is not abrupt. In a big valley such as the Tsangpo valley, for example, it is through tall shrub growth and scattered trees, mostly of small size. The first trees are found high upon the flanks of the ranges and in the side valleys. The sheltered slopes are the first to be covered with forest ; only gradually does the forest descend to the bottom of the valley, the limiting factor here being wind. In the Tsangpo valley itself

the first trees are Junipers, closely followed by *Pinus tabuliformis* which in the side valleys ascends to 10,500 feet. At 9,000 feet, *Pinus tabuliformis* is replaced by *P. Armandii*. *Abies Webbiana* is found close to the river above Tsela Dzong, at 10,500 feet, and higher up becomes the dominant tree. In Tsari, *Abies* and Juniper are the first trees to appear, rather abruptly. Approaching the river gorge region from Shugden Gompa, however, the first forests are composed of *Picea lichiangensis* with Poplar (*P. alba*) along the lake margin. In the Yigrong gorge, *Pinus excelsa* and *P. tabuliformis* grow together with a big *Rhododendron* on the exposed side, *Tsuga Brunoniana* on the sheltered side: and this forest gives way abruptly to *Quercus Ilex* forest as the dry plateau is approached. Higher up the gorge *Picea-Abies* formation is reached towards the alpine region.

Further north a woodland climax formation is interpolated between scrub and forest climaxes, as around Gyamda. The dominant trees are *Betula*, *Juniperus*, and *Quercus Ilex*, none of them exceeding thirty feet in height. Other small trees or large shrubs are *Prunus*, *Sorbus*, *Hippophaë*, with large shrubs such as *Salix* (2 species), *Lonicera* (3 species), *Myricaria*, and small shrubs, *Rosa sericea*, *Spiraea*, *Berberis*, *Caragana*, *Cotoneaster*, *Wikstroemia*, and *Ribes*. Herbaceous plants which grow beneath the canopy are *Adenophora*, *Thalictrum diffusiflorum*, *Androsace*, *Salvia*, *Codonopsis*, *Allium*, several ferns, *Aster*. On the cliffs *Gentiana Waltonii* is common, with *Saxifraga*, *Didissandra*; on gravel terraces *Salvia Wardii*, *Dracocephalum Hemsleyanum*; in bogs *P. Florindae*. The transition from plateau to river gorge climate, gradual in the valleys, is still more gradual on the great mountain ranges which pass out from the plateau eastwards—though abrupt when crossing a rain screen such as the Himalaya. If, however, we cross the Great Himalayan range well within the river gorge region—say, east of the 93rd meridian,—we merely pass from one forest climax to another*. As the plateau ranges bend round towards the south-east †, the flora gradually becomes richer, with new genera and species appearing. But it is still an alpine tundra climax.

The River Gorge Region; General Description.

The upper gorge country is comparatively dry and covered with a continuation of the plateau thorn scrub, though richer

* This is unique in the whole 1,500 miles of the Great Himalayan range. The Assam Himalaya, trending north-eastwards, is about 250 miles in length, from the Bhutan frontier to the gorge of the Tsangpo. For the last 150 miles, the main range is forested on *both* sides.

† South on maps, where they are shown as meridianal ranges between the southward flowing rivers of Eastern Tibet.

in species. Trees are at first rather scattered, or confined to favourable localities where there is underground water, or protection from a too scathing wind. They increase in variety as the moister atmosphere is approached; their dominance becomes marked; forest prevails. Thus the Tsangpo valley from the 93rd meridian eastwards to Tsela Dzong, and the Gyamda valley, belong to the upper gorge region, and show the transition from thorn scrub to forest. So also the headwaters of the Subansiri, except the Tsari valley, which is well forested throughout and belongs entirely to the lower gorge region. The 93rd meridian marks the westward limit of the river gorge region fairly accurately, just as it marks the westward limit of the ice cap. Here the climate, and therefore the vegetation, conforms more closely to the physiographical boundary. The southern limit of the river gorge region, within the Tibetan frontier, lies along the range south of the main Assam Himalayan range; and the province of Mönyul, which is densely forested, reaches to within fifty miles of the plains. The southernmost valleys of Mönyul descend to 5,000 feet, and are filled with Pine-Oak (*Pinus excelsa* and *Quercus Griffithii*) forest; while the hill ranges, rising to 12,000 or 14,000 feet, are covered with *Tsuga*, *Rhododendron*, and *Abies-Picea* forest. Many Sikkim plants such as *Buddleja Colvillei*, *Rhododendron Lindleyi*, *R. Falconeri*, *R. grande*, *Bryocarpum himalayense*, *Magnolia Campbellii*, *Berberis insignis*, *Primula mollis*, and others extend east of Bhutan into Mönyul.

In the Assam Himalaya also *Cupressus torulosa* occurs.

The country lying between the Tsangpo and the Gyalam (Lhasa–China high road) is rather different from anything south of the river. Here are no gorges. A single range of mountains divides the Tsangpo valley from that of the Gyamda river: and from it wide shallow glaciated valleys run down on either side. Small lakes, some of them situated in hanging valleys, shrunken glaciers, and the long ice-worn valleys tell of the former extensive glaciation of this region. The alpine flora is that of the plateau ranges rather than of the river gorge region, for the climate is harsh: but the side valleys as they approach the Tsangpo to the south, and the Gyamda valley to the north, as indeed the Gyamda valley itself, are well wooded with Birch, Oak, Juniper, and Pines forming a woodland climax.

The northern limit of the river gorge region is more difficult to define, but it lies not far from the 31st parallel of north latitude. The Gyalam skirts it closely, nowhere penetrating it to any depth. In the Gyamda valley, and perhaps east of Chamdo, it traverses the fringe of the dry upper gorge country. Eastwards the river gorge region extends through

Chinese Tibet to Tatsienlu in Szechuan. By far the greater part of the Tibetan flora is concentrated in the river gorge region. Like that of the outer plateau, it is divisible into two main types, which are much more sharply contrasted than those of the plateau.

The contrasted types are the forest flora of the moist and warm gorges themselves and the alpine flora of the high ranges which enclose them. These extreme types of course are connected by a whole series of intermediate types. The river gorge region might as justly be called the mountain region of Tibet. But since it is the gorges which most impress the traveller, and which mainly assist or impede his progress, I have used the former designation.

In the river gorges Tibet reaches its lowest altitudes ; only here, indeed, does the altitude sink below 10,000 feet. Thus the Tsangpo, at the lower end of the great gorge, near Gompo Ne, flows at an altitude of no more than 6,000 feet. The Lohit, at Rima, is flowing at 4,000 feet *. The Taron gorge at the sources of the Irrawaddy is 4,000–5,000 feet above sea-level. The Salween at Menkung, immediately to the east of the Taron, 5,000–6,000 feet : and its big tributary, the Dayul Chu, to the east again, is not much higher. The Mekong in the same latitude is 6,000–7,000 feet and the Yangtse 7,000–8,000. This progressive rise in the altitudes of the river beds as one travels eastwards is peculiar and cannot be accounted for by a progressive increase in the size of the rivers from east to west, since the Yangtze is the largest of all and the Salween is larger than the Taron. The river gorges east of the Lohit, though low-lying as compared with the plateau, are by no means moist where they are flowing through Tibetan territory. The Taron, rising further south, does flow through a wet country ; but the gorges of the Salween, Mekong, and Yangtze are very dry, and support a thorn scrub flora similar in appearance to that described for the dry valleys of the plateau proper at 10,000–12,000 feet. These rivers all flow down into Chinese territory ; and there, after they have crossed the great rain screen, the scrub climate becomes a forest climate. Only the Subansiri, Tsangpo, Lohit, and Taron support a warm temperate rain forest flora just within Tibetan territory. In the far west of Tibet, the gorges of the Indus and Sutlej are arid. Within Tibet, the Sutlej flows at an altitude of not less than 10,000 feet, but the Indus flows much lower, owing to the great depth to which it has cut its gorge.

* As already pointed out (*op. cit.*), these rivers rise on the outer rim of the plateau and do not cut through the main mountain axis. Nevertheless, the Lohit almost throughout its course is filled with Coniferous forest.

Alpine Flora of the River Gorge Region.

That the alpine flora of the river gorge region should differ widely from that of the plateau range is intelligible when we consider the very different conditions under which it lives. Whereas the plateau ranges are under snow for three or four months at most, the river gorge ranges are under snow—and to a far lower altitude—for at least six months.

Moreover, during the short growing season the atmosphere is constantly saturated, and the alpine flora grows literally in a mist bath. Direct sunlight is reduced to a minimum. There are only two seasons—summer, with almost continuous cloud and rain, and winter, when the alpine flora is buried under snow *. During the growing season dry winds are lacking. Compare this with the climate of the plateau ranges. Here there are four seasons, early spring, when the melting snow supplies moisture, a wet summer, though with numerous fine intervals, a fine autumn, and a cold winter. Desiccating winds blow during the eight or nine months when the plants are above the snow; the vegetation there probably has to withstand far lower temperatures than ever occur in the river gorge mountains.

The genus *Rhododendron*, of which there are in Tibet about one hundred species, furnishes a rough but useful guide to the average humidity; for whereas all Rhododendrons are xerophytic, some are much more xerophytic than others. On the plateau ranges only about half a dozen species occur. They are mostly pygmy ('dwarf') Rhododendrons, but being gregarious they sometimes cover considerable areas. A few are larger shrubs. In the plateau valleys no species of *Rhododendron* are found. On the other hand, the snow-bound river gorge ranges are covered with a continuous carpet comprising many alpine species. From the forest in the deep gorges to as high as flowering plants ascend there is a great concentration of species, three-quarters of those known from Tibet being found here.

Owing to the low snow-line (about 15,000 feet) and to the great accumulations of snow in the valleys below that level, the alpine flora does not achieve such heights here as it does on the plateau ranges. Rarely does it extend much above 14,000 feet. The plants too are in general less specialized, since they have to withstand neither such low temperature nor the desiccating effect of dry wind. Thus there are fewer cushion, rosette, and even mat plants. It is not surprising

* A fine spell, lasting two or three weeks, in early winter is not uncommon, but by no means constant. Spells of fine weather lasting a week or ten days between snowstorms are normal.

that under such conditions a certain number of endemic genera and species should have developed, even in the short time since the disappearance of the ice. Other species, widespread in Tibet or in Sino-Himalaya, are represented here by distinct varieties. To this region belong, almost exclusively, the Sino-Himalayan genera *Bryocarpum*, *Omphalogramma*, *Notholirion*, and *Cyananthus*; most species of *Nomocharis* and *Cremanthodium*, which also are Sino-Himalyan; most species of *Meconopsis*; and entire sections of *Primula* and *Rhododendron*, which indeed are equivalent to genera. Of the former *P. Agleniana*, *P. falcifolia*, and their near allies and varieties, sections Rotundifolia, Souliei, Dryadifolia, Petiolares, Muscarioides, and the Himalayan representatives of section Soldanelloides and of sub-section Geranioides are confined to the alpine zone of the river gorge region: and of *Rhododendron*, sections Vaccinioides, Maddeni, Cinnabarinium Neriiflorum, Edgeworthii, Boothii, Saluenense, Campylogynum, and Glaucum.

Forest Flora of the River Gorge Region.

The forest flora of south-eastern Tibet, where the great rivers pierce the rain screen, is so rich and varied that it is possible at present to describe briefly only the main types of forest met with. There is also a meadow association. The forest may be divided into two types—'wet' forest and 'dry' forest. The former includes *Tsuga-Rhododendron* forest, mixed Conifer forest, *Quercus-Rhododendron* forest, broad-leafed deciduous forest, and *Abies* forest; the latter, *Pinus Khasia* forest, Birch-Oak forest (*Quercus Ilex*), *Pinus-Tsuga* forest, and *Picea* forest. Where Conifers comprise less than half the forest, it may be distinguished as warm temperate forest or temperate rain forest; but such forests are found only lining the rivers in the deepest gorges. All types of wet forest contain a large proportion of Rhododendrons, especially tree species and small evergreen shrubs, and in the warmest valleys epiphytic species occur. In the dry forest Rhododendrons are much less conspicuous, being fewer, smaller, and in less variety. None of the forest types occupy extensive superficial areas; rather do they occur in altitudinal zones. Thus it is impossible to distinguish more than 'wet' and 'dry' forest areas on a small-scale map.

If we follow the eastern rivers a little further, beyond the Tibetan frontier, where the gorges begin to widen in Yunnan, Burma, and Assam, we find them clothed with temperate rain forest and hill jungle, at altitudes ranging between 3,000 and 6,000 feet, e.g. the Salween in latitude 28° where it flows into Yunnan, the Taron of northern Burma, and the Lohit and Tsangpo (or Dihang) which reach Assam. Within the

Tibetan frontier (whether *de jure* or *de facto*) such temperate rain forest is found only in the Assam Himalaya in the province of Mönyul, and in Zayul; though the forests of the upper Taron, of the lower Tsangpo gorge, and the Po country generally are not very dissimilar. Nine types of forest are distinguished, five being regarded as 'wet' forest and four as 'dry' forest.

Wet.

I. *Acer-Magnolia Forest* *.

In the Tsangpo gorge *Magnolia rostrata* is found together with *Acer caudatum*, *A. stachyophyllum*, and other species. Characteristic of this formation are *Pinus excelsa*, *Quercus incana* (and other oaks), *Bucklandia populnea*, *Albizzia Wardii*, *Erythrina arborescens*, *Alnus nepalensis*, *Ficus*, *Betula*, *Saurauja*, *Viburnum*, *Arundinaria*, *Rhododendron Nuttallii*, and other species. A similar type of forest is seen in Zayul, where *Acer Hookeri* and *A. Campbellii* are associated with *Magnolia Campbellii* and *Michelia lanuginosa*. Other trees here are *Carpinus viminea*, *Schefflera shweliensis*, *Cedrela*, *Litsaea*, *Ailanthus*, *Ilex*, *Pinus excelsa*, *Abies Pindrow*; together with many shrubs, such as *Symplocos*, *Philadelphus*, *Deutzia*, *Viburnum*, *Jasminum*, *Ligustrum*, and *Rhododendron bullatum*.

II. *Quercus-Rhododendron Forest.*

In the Yigrong gorge a big-leafed evergreen Oak is associated with a big-leafed tree *Rhododendron* (perhaps *R. niphargum*), and several trees of sub-tropical affinity, such as Laurels. *Cedrela* occurs commonly, also *Taxus Wallichiana*, *Juglans regia*, *Rhododendron tanastylum*, *Pinus excelsa*, *Tsuga Brunoniana*. Associated with these are many woody climbers, such as *Vitis*, *Schizandra*, *Clematis*, *Lonicera*, *Ficus*. In the undergrowth occur such plants as *Chirita*, *Sarcococca Hookeriana*, *Caulophyllum robustum*, *Monotropa*; together with epiphytic Gesneraceae.

III. *Tsuga-Rhododendron Forest.*

In the eastern Himalaya *Tsuga Brunoniana* sometimes forms pure stands with tree *Rhododendron* (*R. sino-grande*) gregarious beneath. Scattered through such forests are other trees, mostly smaller. *Larix Griffithiana* occurs here, too, especially on the southern slope of the Assam Himalaya;

* I have named the formations after the *apparently* dominant *genus* (it should, of course, be species in accordance with modern ecological practice). Future intensive study may show that one of these is not dominant here. But at least a start has been made, and investigators will have something to go on.

together with Birch (*Betula utilis*), *Acer* spp., Laurels, *Prunus vestita*, several Celastraceae, *Aristolochia Griffithii*, and many small Rhododendrons.

IV. *Abies-Juniperus* Forest.

These frequently share the limit of trees, *Juniperus* occupying the more exposed places. This type of forest is open, and as a climax formation is engaged in a perpetual struggle with alpine meadow and shrub growth. On the more exposed slopes *Rhododendron sigillatum* is gregarious, and *Betula* also occurs.

V. *Abies-Picea Forest.*

Sometimes *Picea* rather than *Juniperus* occupies with Silver Fir the tree limit. There is usually an alpine scrub of some deciduous species, *Betula* or *Acer* or both growing gregariously, and also an evergreen *Rhododendron* scrub.

Dry.

VI. *Picea-Betula Forest.*

In Nagong, on the edge of the forest country, *Picea lichiangensis* is often the highest tree, usually mixed with Birch. *Larix Griffithiana* may be present, though it is not dominant. The only large *Rhododendron* is *R. vellereum*. Mixed with the trees are a number of shrubs, species of *Rosa*, *Lonicera*, *Berberis*, *Spiraea*, *Caragana*, and others.

VII. *Pinus Quercus Forest.*

Forests of pure *Pinus Khasia* are found in the Lohit valley, above and below Rima. The valley lies very low, Rima itself being under 5,000 feet. The summers are hot, fierce drying winds blowing up through the gorge, and there are periods of drought, in spite of a moderately heavy rainfall. The winters are cold, with night frosts and occasional snow; but there is two or three months' dry weather between October and Christmas. The commonest oak appears to be *Quercus glauca*. It is impossible at present to say whether this is a climax formation; the fact remains that the hillsides are burnt every winter, and this must have a marked effect on the vegetation. At a little height above the valley bottom the forest is much more varied, with *Abies Pindrow*, *Rhododendron arboreum*, *Prunus Puddum*, and most of the trees recorded in I. above. Pure *Pinus Khasia* stands occur also in the Tizu valley, Naga Hills, as an undoubted fire climax; but here the associated trees are very different. *Pinus Khasia* does not occur in the Himalaya.

VIII. *Mixed Pine Forest (Pinus excelsa–Pinus tabuliformis)* *.

This occurs in the Yigrong gorge. The dominant trees on the open side of the valley (which runs E.–W.) are Pines; on the sheltered side *Tsuga Brunoniana*. Other trees are Poplar, *Quercus Ilex*, *Larix Griffithiana*, *Picea*, *Salix*. Shrubs include *Syringa*, *Rhododendron megacalyx*, *Rosa sericea* and *R. Moyesii*, *Lonicera*, *Ribes*.

IX. *Quercus-Betula Woodland.*

This occurs in the comparatively dry cold valleys on the northern and western borders of the river gorge country, e.g. at Gyamda and along the Lhasa–China road. This formation has already been described (p. 150).

In conclusion it may be remarked that the flora of Tibet, being largely alpine, is predominantly northern. The Chinese element, if that term means eastern Asiatic, is not large; though the *alpine* flora of Tibet has many species which extend into western China. In the lower gorge country, there is a considerable Indo-Malayan element, which can be traced on to the outer plateau in such genera as *Incarvillea*, *Amphicome*, and other Gesneraceae.

The paucity of endemic families in Sino-Himalaya †, and of genera, may be attributed to the brief existence of this flora under novel conditions.

But the origin and distribution of the Tibetan flora is another study.

EXPLANATION OF THE PLATES.

Plate 6.

A. The Po-Yigrong in the river gorge region, at 8,000–9,000 feet, with mixed Pine forest (*P. excelsa*, *P. tabuliformis*), *Tsuga*, and broad-leafed trees.

B. The Tsangpo valley, in the river gorge region, at 10,000 feet. *Hippophaë*, *Quercus Ilex*, and other broad-leafed trees, mixed with *Pinus tabuliformis*.

Plate 7.

A. Alpine ranges of the outer plateau. North slope of the Pen La, Great Himalayan range, at 15,000–16,000 feet. Scattered cushion plants such as *Chionocharis*, *Androsace*, etc.

B. Valley of the Tsangpo, outer plateau, 10,000–11,000 feet. Xerophytic herbaceous plants, sand-binding grasses, etc. Here grow *Onosma Waddellii*, and *Oxytropis sericopetala*; also the shrub *Pteropyrum*.

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* A curious Pine with the cone of *P. Khasia*, but only two needles.

† Two only: Sargentodoxaceae in western China, Circaeasteraceae in the Himalaya and Tibet. Each with one genus and one species.

A

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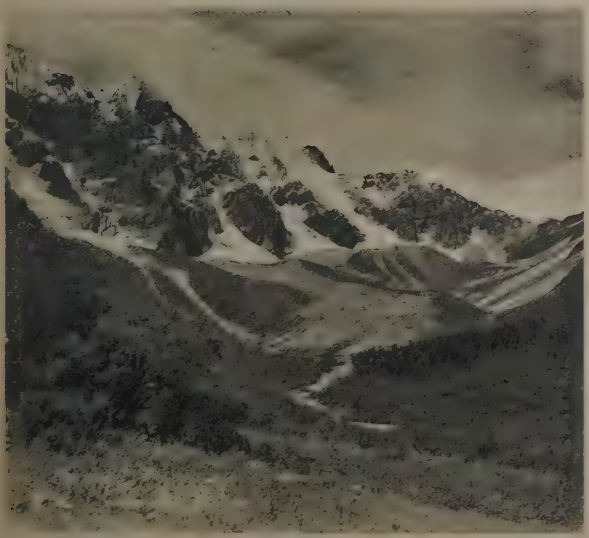

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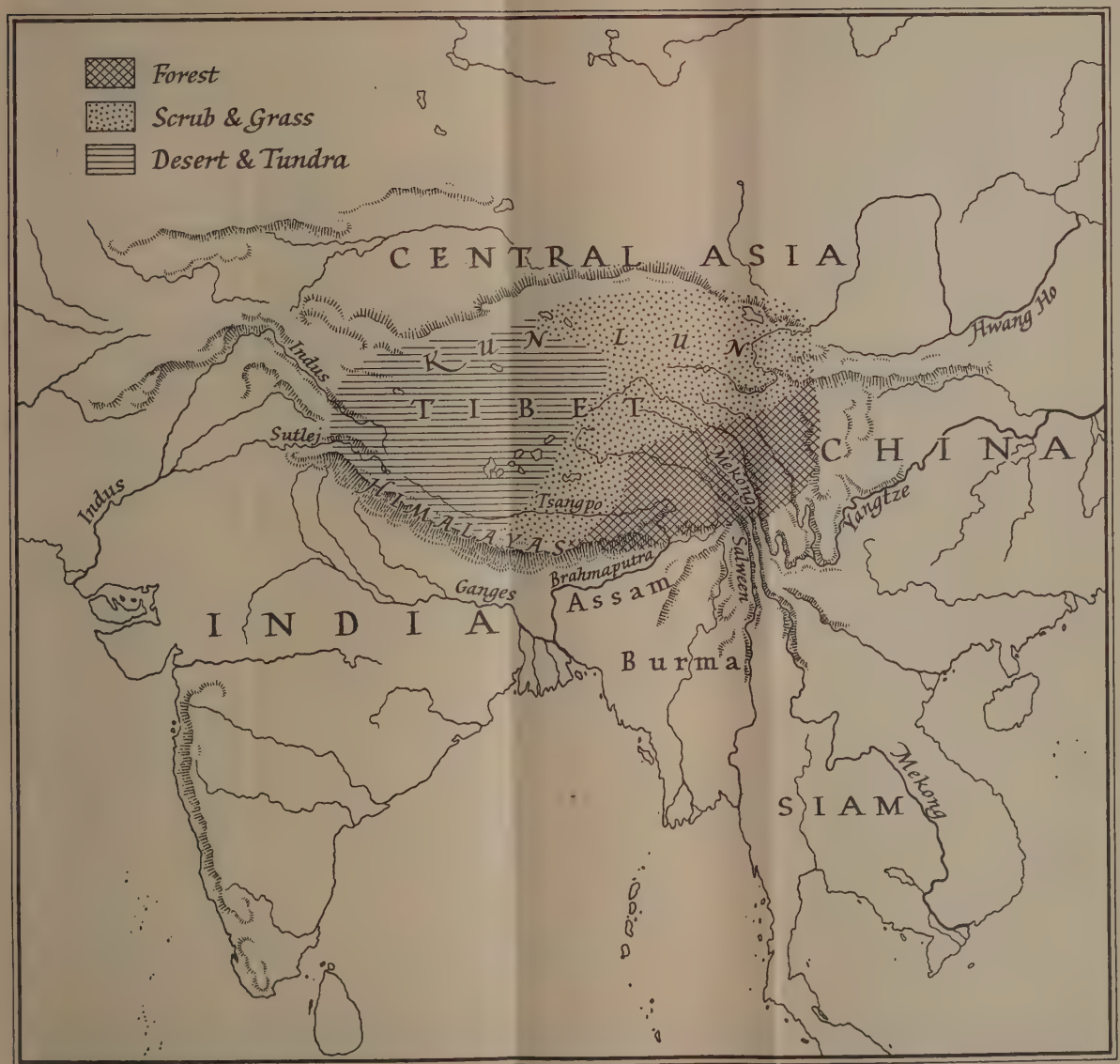

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PLATE 8.

A. Alpine range in the river gorge region, Assam Himalaya, southern slope. *Primula strumosa* colouring a yak pasture at 14,000 feet.
B. Alpine range in the river gorge region, 15,000 feet. Meadow with patches of trees—*Salix* and *Abies* at the tree limit.

PLATE 9.

A. Alpine meadow in the Tsari valley, river gorge region, 12,000 feet, showing *Primula alpicola violacea* and *Iris Delavayi*.
B. Alpine Rhododendron scrub on the outer plateau ranges, at 13,000–14,000 feet (*R. sigillatum*, etc.).

Mr. I. H. BURKILL recalled the confusion in which phytogeographers are as to the boundaries of botanical regions and subregions in the interior of Asia, and remarked on the great value, this being so, of Captain Kingdon Ward's observations. Then referring to the lecturer's statement that bulbous plants are rare, whereas plants with a large part of their body underground are common, he asked if it were not possible for rhizomatous plants to succeed better than bulbous and tuberous plants in a climate of great rigour because the former adjust their positions and appropriate the best of their little patch of soil in a way denied to a plant which lives and dies exactly where its embryo escaped from the seed.

Mr. C. GILBERT ROGERS, after having paid a tribute to the great indebtedness of botanists to Captain Ward for the comprehensive additions to the Flora of Tibet made by him under very great physical and other difficulties, which a less determined and less experienced explorer would not have been able to surmount, said he had been much struck by the similarity of the zones of vegetation—depending upon altitude—in Tibet and on the northern slopes of the Kilimanjaro and Kenya mountains in East Africa, which he had recently had an opportunity of visiting.

In both regions there was on the lower slopes of the mountains a zone of High Forest, of differing degrees of moistness, succeeded by a belt of dry scrub forest, which in its turn gave way to grass with a varying admixture of small herbaceous plants, many of which had rosettes of radical leaves. Above the grass the only vegetation was lichens on the rock masses.

Similarly, at the highest elevations where wood fuel could be obtained—with the exception of the tree Senecios—it was from the underground swollen rootstocks of Ericaceous species, which owing to their being burnt over periodically, only threw out short, thin, whip-like stems.

The elevations at which the various zones of vegetation were found corresponds fairly closely in Asia and Africa.

Dr. A. B. Rendle referred to the lecturer's remarks that at the higher levels trees were found only associated with human habitation, and asked what crops were cultivated and whether any system of rotation was followed.

Mr. Ramsbottom said that he would like to add how much all must have appreciated the beautiful slides shown by Capt. Kingdon Ward. To appreciate them fully it was necessary to bear in mind the extremely difficult conditions under which the photographs were taken. It was the same with the very fine herbarium specimens which the lecturer had brought back with him. Anyone with experience of collecting even in this country knew the troubles likely to arise from insect and fungus attack. To have to transport plants over the sort of country shown in the slides and to keep them in good condition must mean an enormous amount of labour. The lecturer certainly excelled in one branch of botany 'especially associated with the name of Sir Joseph Hooker'.

7 May 1936

Dr. W. T. Calman, C.B., F.R.S., President, in the Chair

The Proceedings of the General Meeting held on Thursday, 23 April 1936, having been circulated, were taken as read and confirmed.

The President stated that the Fellows would hear with regret of the illness of the Assistant Secretary, Mr. S. Savage.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following candidates, whose names were read for the third time, were balloted for and elected Fellows:—Thomas Edward Hughes, Paulus Edward Pieris Deraniyagala, M.A., Neil Alison Mackintosh, D.Sc., A.R.C.S., Donald Vanstone, B.Sc., A.R.C.S.

The following candidates, whose names were read for the third time, were balloted for and elected Foreign Members:—Boris Aleksyevich Fedchenko, Merritt Lyndon Fernald, Paul Pelseneer, Karl Freiherr von Tubeuf, William Morton Wheeler.

The following candidate, whose name was read for the third time, was balloted for and elected an Associate:—Maude Jane Delap.

Natural Hybrids of Primula elatior Schreb.

By Dr. R. Melville (Visitor).

Before entering on a discussion of some of the naturally occurring *Primula* hybrids, it will be well to review some of the distinctive characters of the primrose, *P. vulgaris* Huds., and the oxlip, *P. elatior* Schreb.

In the primrose the flowers arise singly and are pale yellow with a strongly marked pentagonal 'eye' spot surrounding the mouth of the corolla-tube. The petals are rounded, emarginate, and overlap one another. The calyx is strongly ridged, somewhat contracted at the mouth, and pale green. The leaves are elliptic with the lamina markedly decurrent along the petiole. Calyx, flower pedicels, and leaves are covered with a rather long shaggy indumentum.

The oxlip bears its flowers in a nodding umbel, never singly as in some hybrids. The individual blooms are smaller and of a deeper yellow than the primrose, with petals that are but slightly rounded, and often with nearly parallel sides. This form results in the petals being distinct or overlapping very little. The 'eye' spot is an indefinite diffuse orange-yellow region at the mouth of the corolla. The calyx is almost cylindrical and not contracted at the throat. The ridges are not so prominent and the colour a deeper green than in the primrose. The leaves are elliptical and rather sharply contracted to the petiole. Calyx, pedicels, peduncle, and leaves are covered with a much shorter indumentum than that of the primrose.

The oxlip has a limited distribution in Great Britain, where it is confined to two main areas, on the calcareous boulder clay of East Anglia. There is, in addition, a small number of outlying stations quite near the main area of distribution. Our knowledge of the distribution of the oxlip is due largely to the careful work of R. Miller Christy, who published his conclusions with a map in the 'Journal of Ecology', x, 1922. The plant is usually found in open woods, but in certain of the outlying stations it appears in boggy meadows bordering some of the many small streams draining off the boulder clay covered heights. Miller Christy emphasises that the primrose does not occur within the main oxlip areas, and my observations, so far as they go, support his statement. Hybridisation, therefore, can take place only at the fringe of the oxlip area where the two species meet. The cowslip (*P. veris* L.), on the other hand, extends over the whole of the oxlip range and beyond. In my experience, cowslip hybrids are frequent.

Near the village of Quendon on the western edge of the main oxlip area is a wood which was coppiced about eight or ten years ago. Here a great number of hybrid forms have appeared

during the last few years. On the western side of the wood the *Primula* population consisted of primroses, a few oxlips, and a large number of hybrids. Many of the latter were evidently the first cross, but a fair number of plants were back crosses or segregates of some later generation. On proceeding eastwards through the wood the nature of the population changes. More oxlips appear and fewer primroses. At about 300 yards from the western edge there were very few hybrids with evidence of a primrose parentage, but many oxlips and a sprinkling of hybrids showing characters of the cowslip.

The F_1 generation of the oxlip-primrose cross produces handsome umbels of flowers. The individual flowers resemble the primrose in size, colour, and petal type, and bear the characteristic pentagonal eyespot. The umbel is spreading and the separate pedicels are longer than in the oxlip. The form of the calyx and of the leaves is intermediate, but the shaggy indumentum of the primrose is a prominent feature of the hybrid. Though the flowers normally are borne in umbels, occasionally plants are found bearing both umbels and single primrose-like flowers. Such plants usually produce the single flowers early in the season and the umbels later. More rarely, plants with irregular inflorescences appear. A flower or two may arise from the scape below the umbel or the umbel may be replaced by a raceme as in the examples shown. It will be evident from the above remarks that the caulescent habit is incompletely dominant in this hybrid.

Among the hybrids of uncertain status was a group bearing loose umbels of flowers with very narrow petals and red stigmas. These were probably the progeny of a single plant. The appearance of red anthocyanin pigment is interesting, as the oxlip bears a colour inhibitor. The oxlip parent may have been heterozygous in this character, but it is also possible that pollen was brought from some coloured garden form in the neighbouring village. Pollen must have been brought from near by meadows, about equally distant, since plants of the hybrid cowslip × primrose were found in the wood. Other hybrid plants showed various combinations of characters indicating that they were back crosses or segregates of an F_2 or later generation. Others, again, appeared to be segregates from crosses in which the cowslip was one of the parents. Among the latter was a small group of plants bearing rather small rounded dark green leaves with a shiny glabrescent surface. The flowers were about the size of oxlips, but the calyx was short and inflated and several other characters recalled the cowslip.

Abnormal characters appear sometimes in hybrid plants.

A plant found in another wood near Quendon, and brought into the garden, bore several single long-stalked flowers with foliose calyces and six petals. These arose between normal leaves springing from the end of a short branch. When photographed two years later, the plant was bearing an umbel which at first glance appeared normal, but the floral parts were in sixes instead of fives. When first seen, the normal part of the plant had two small umbels with non-foliose calyces. The abnormal branch may have been due to somatic segregation and appears to have died later. The leaves with glabrescent upper surface and certain floral characters, especially the type of pubescence and inflated form of the calyx, point to a cowslip parentage for this plant.

Another abnormal hybrid bore an umbel with one polypetalous flower and two others with the corolla-tube slit to the base on one side. The remaining flowers were either normal or slightly zygomorphic. The plant, now in the garden, has since produced flowers which were slightly zygomorphic. Here, again, on account of various characters, the cowslip must have been one of the parents.

In the spring of 1936, two of the outlying stations for the oxlip, near Tuddenham and Cavenham respectively, were examined. In both places the plants were growing in boggy meadows by the sides of small streams in the company of species of *Juncus*, *Carex*, and *Spiraea Ulmaria*. In the drier parts of the meadows cowslips were common. The oxlip population was a confusing mixture of hybrid forms in which the cowslip was evidently a parent.

The F_1 hybrid between the oxlip and cowslip exhibits an assortment of characters from its parents and is intermediate in others. The flowers are as large as oxlips and borne in a spreading umbel as in the cowslip. The corolla is slightly darker than the oxlip with the lobes more rounded. The diffuse orange eye-spot appears and the orange-red streak along the midrib of the petal as well. The streak is not as dark as in the cowslip. The calyx is inflated, paler in colour than in the oxlip, with broader teeth approaching the cowslip type. The leaves are generally more orbicular than in the oxlip, and leaves and other parts bear the oxlip type of hair which is quite distinct from the very short pubescence of the cowslip. In many hybrids, probably segregates, the leaves are orbicular, dark green, and shining on the upper surface, but bear short hairs of the oxlip type.

When comparing hybrids with the parent species, pin-eyed forms should be compared with pin-eyed and thrum-eyed with thrum-eyed. Thrum-eyed oxlips have a calyx broader and slightly shorter than in the pin-eyed form. The inflated

calyx of the hybrid contrasts more sharply therefore with the narrow cylindrical calyx of the pin-eyed oxlip.

It has been recognised for a long time that the primrose and oxlip will hybridise freely wherever they come into contact. Miller Christy considered the oxlip × cowslip hybrid to be infrequent in the field. His statement is not borne out by an examination of oxlip communities, and it appears from the evidence that this cross can take place just as readily as that with the primrose.

Sir Arthur W. Hill referred to the excellence of Dr. Melville's photographs and the singular beauty of the oxlip woods near Cambridge. He referred also to the characteristic scents of the oxlip, cowslip, and primrose as an aid to their identification. He mentioned that he had discovered a well-marked hybrid between the oxlip and the cowslip in the outlier at Great Livermere, which he had described and figured in 'The New Phytologist', vol. vi, 1907, and pointed out the very characteristic throat coloration and markings in the three species which could be detected, as Dr. Melville had mentioned, in the hybrids.

Mr. A. J. Wilmott said that he had never been able to understand Miller Christy's statements that the areas of the primrose and oxlip did not overlap. In the Cambridgeshire woods known to him the two species were thoroughly intercrossed, e.g. in Gamblingay and Hardwicke woods. Sent to Kingston wood as a pure oxlip wood, he entered it over a recently coppiced carpet of primroses! As regards the scent, he recalled that one name for the oxlip was *P. inodora*.

Mr. H. W. Pugsley pointed out that, while the oxlip is a very local plant in Britain and confined to woodlands, in Switzerland and south Germany it is the commonest species of the group and grows, not in woods, but in open grassland.

Mr. H. S. Meyer (Visitor) asked if it made any difference to the resulting hybrid which way a cross was made?

He had noticed two fairly distinct types of hybrid, the one having the pedicels coming out at right-angles from a short peduncle, the other having them rising upwards from a longer peduncle, and wondered if the short one was the offspring of a primrose plant pollinated by an oxlip and the other, the taller one, of an oxlip plant pollinated by a primrose.

Mr. T. A. Dymes said that he shared Mr. Wilmott's interest in the fertility of the hybrids, as he had found that the seeds did not germinate or produced only sickly seedlings, which died in infancy: in his experience *P. elatior* had but a slight fragrance, whereas the hybrids with *P. veris* sometimes smelt strongly of peaches. He asked if Dr. Melville agreed that this hybrid was the rarer of the two and whether he thought

that the later flowering of *P. veris* might be the cause. He added that in 1934 *P. elatior* had been found near Potton in Bedfordshire, together with the $\times$*P. vulgaris* : this was a new county record, and he believed that it was the only one of the known outlying localities that was south of its own main area ; seeds of the Potton hybrids sown in September of that year, 1934, had, up to date, failed to germinate.

Mr. I. A. Williams, referring to Mr. Pugsley's remarks, said that he had seen the oxlip as a woodland plant in the department of the Somme in France.

In his reply, Dr. Melville said that the odour of the flowers is not a character that he had followed up. It would be of interest to find out what differences there are in the perfumes of the hybrids and segregates.

There can be no question that the hybrids are fertile. This is demonstrated by the variety of hybrid forms seen in the field. The fertility of the hybrids, however, is not nearly as great as that of the parents. He had reared and flowered plants from the seed of hybrid parents.

The form of the umbel in the hybrid, primrose $\times$ oxlip, is a good character for distinguishing such plants. The umbel is upright and spreading instead of nodding. The pedicels are long and bear the shaggy indumentum of the primrose.

The difference in the habitat of the oxlip growing in the open on the Alps and in woodlands in this country is striking. It may be suggested that as the oxlip is a northern species, temperature may have something to do with this. While the temperature is suitable in the open on the Alps, cool enough conditions may occur in the lowlands, only in woods or along stream sides. It is true that the oxlip comes into flower before the cowslip, but the flowering season of the two species overlaps considerably. There is ample time for cross pollination to take place.

The structure and reproduction of Chaetangium saccatum (Lam.) J. Ag.—I. Vegetative structure and male plants. By Margaret T. Martin, M.Sc. (Westfield College, University of London). (Communicated by Dr. E. M. Delf, F.L.S.)

[Plate 10]

Introduction.

It is generally assumed that the group Nemalionales consists of haplobiontic types, where reduction division occurs immediately after fertilisation and the asexual spores, if present, take the form of accessory monospores. This was

first shown by Svedelius for *Scinaia furcellata* (1915), and more recently by the same author for *Bonnemaisonia asparagoides* and *Asparagopsis armata* (1933); similar evidence has been furnished for *Nemalion multifidum* by Kylin (1916) and Cleland (1919), and for *Batrachospermum moniliforme* by Kylin (1917). It is clear, however, that there are forms amongst the Nemalionales which differ very much in complexity. The families Batrachospermaceae, Lemaneaceae, and Helminthocladiaceae consist of genera which are relatively simple both in construction of the thallus and in formation of the cystocarp. In the Naccariaceae, Bonnemaisoniaceae, and Chaetangiaceae, however, we find an increase in vegetative complexity and an elaboration of the gonimoblast and cystocarp; these may be regarded as 'higher' types, in contrast to the simpler or 'lower' forms.

Apart from the accounts mentioned above, our knowledge of the Nemalionales is rather scanty. The Chaetangiaceae, in particular, which appears to occupy a position amongst the 'higher' Nemalionales, is a little known family, and *Scinaia* is the only member which has been described in any detail. Other genera usually placed in this family would seem to have especial interest in view of the fact that *Galaxaura* bears tetraspores, and, moreover, these are borne on separate plants, quite distinct from the sexual individuals. Some significance may also be attached to the presence of tetraspores in *Liagora tetrasporifera* (Helminthocladiaceae), where they terminate the gonimoblast filaments (Börgesen, 1927). The systematic position of both these genera must rest in abeyance, pending further investigation of their cytology.

Of *Chaetangium* itself practically nothing is known, and the opportunity has therefore been welcomed of undertaking an investigation of *Chaetangium saccatum*. Ten species of *Chaetangium* have been recorded (de Toni, 1897, 1924); these occur mostly in the South Indian Ocean and South Pacific, but three of them are found only in South Africa, and *C. saccatum* is one of these. Harvey (1838) records this species under the name of *Dumontia saccatum* in his 'Genera of South African Plants' and Kützing (1866) as *D. capensis*, the latter author giving a figure (of low magnification) of a transverse section through a cystocarp. Schmitz and Hauptfleisch (in Engler and Prantl, 1897) give a short account of the genus, but there exists no description of the structure and reproduction, and asexual spores and antheridia have up till now been unknown. The antheridia, together with the vegetative structure of the thallus, are described here, and it is hoped later to follow this by an account of the female plants and the development of the cystocarp.

Material and Distribution.

Chaetangium saccatum (Lam.) J. Ag. is apparently confined to the South African coast, and has been recorded only in the region of the Cape Peninsula, i.e. from False Bay on the east side round to Table Bay on the west, and along the coast north of Table Bay to Melkbosch Strand. It is less abundant than *C. ornatum*, which is found in the same locality, and unlike that species is more frequent on the western side of the Cape, i.e. in the colder currents from the south, than on the eastern side which is under the influence of warm currents from the Indian Ocean. Delf and Mitchell (1921) have seen it growing at Camps Bay on the west, in association with *Splachnidium*, where it was fruiting freely; they observed that it was less common on passing round to Sea Point, and found only small dwarfed sterile plants at Kalk Bay on the warmer eastern side. These observations have been confirmed by Miss E. L. Stephens, who also notes that the isolated plants found on the east side are always sterile *. She points out, too, that the decrease in the number of plants at Sea Point may be due to the change in the rocks from granite to smooth steeply tilted slate, which does not offer so good a foothold; at Kalk Bay, however, the substrate is sandstone and the foothold very favourable, so that the scarcity of plants there cannot be attributed to this factor. *Chaetangium saccatum* occurs at lower tide levels than does *C. ornatum*, being found from mid-tide level down to low water. The plants are found sometimes in shallow rock pools, but usually on bare rock faces (Plate **10**), though in such latter situations they are often covered with the thalli of *Porphyra*, which keep them from undue desiccation during periods of exposure.

Plants for the present investigation have all been collected by Miss Stephens from Table Bay, on the colder west side. They grew for the most part on tilted slate rocks, and were thus protected to some extent from the direct vertical rays of the sun; several collections were also made from Bantry Bay, where the substrate was granite and where the rock surfaces were horizontal, so that the plants were exposed to much more intense insolation; those in direct sunlight in this locality became hard and dry between tides, but those protected by *Porphyra* remained fresh and damp. Plants

* It is possible, however, that these plants recorded as 'sterile' were really male, for as explained later (p. 169) it is extremely difficult to recognise male plants in the field, and no mature sterile plants have been found in the material examined.

were collected at fortnightly or monthly intervals throughout the year, and were fixed on the shore as follows :—

(1) A weak *chromic-acetic mixture* consisting of :—

1 per cent. chromic acid	25 c.c.
1 per cent. glacial acetic acid	10 c.c.
Sea water.....	65 c.c.

Material was fixed in this solution for twenty-four hours, washed in sea water, and transferred gradually to fresh water for twenty-four hours ; it was then preserved in an alcohol glycerine mixture for transit. Although good fixation was obtained by this method, difficulty was found in differentiating between nuclei and plastids, especially in developing cystocarps and carpospores. The later samples were therefore fixed in one of the two following :—

(2) *Flemming's weaker solution* made up in sea water. Material was fixed for one hour, and washed as above.

(3) *Formalin acetic alcohol*, in which the material was left until examined.

The plants were generally slit up before fixing (or the tips and bases cut off) and an effort made to squeeze out the air.

Much difficulty has been experienced in obtaining microtomed sections owing to the rapid absorption of water by the gelatinous thallus ; this causes curling and folding of the sections, and often results in their floating off during staining. Though the folding has never been entirely overcome, the floating off has been obviated by hastening as much as possible the process of staining and dehydrating. Haidenhain's hæmatoxylin was found to be the most useful stain, with a background of light green or safranin. Comparison with thin hand-sections was necessary, especially in the male plants where the delicate gelatinous walls are apt to become shrunken and folded in embedded material.

Vegetative Characters.

Each plant of *Chaetangium saccatum* is an erect hollow sac 2·5–3 cm. high (rarely as much as 5 cm.). The apex is rounded and obtuse, and the plant narrows towards the base to form a very short stalk attached to the substratum by a small disc-like hapteron. Regeneration often takes place from the basal disc, and several new erect thalli are put up ; more rarely new shoots grow out from the upper part of the erect hollow plant ; and occasionally specimens have been found in which numbers of these proliferations have resulted in a branched bushy appearance.

The plants are always dioecious. Mature female plants are easily recognized by the ripe cystocarps, which can be seen with the naked eye as small opaque spots scattered over the surface ; on slitting up the plant these are seen to be lumps projecting into the central cavity. Apparently all plants which are not female are male ; no sterile or asexual plants have been found amongst the mature material examined, and there seems every reason to believe that there is no asexual stage in the life-history. The male plants are about the same size as the female, and are chiefly to be recognized by the absence of cystocarpic lumps ; their surface when examined closely has a dull patchy appearance, but it would be very difficult in the field to distinguish this from the appearance produced by the abundant small epiphytes on the surface.

From quite an early stage in development, the plant consists of a hollow sac, with a very large central cavity and a comparatively narrow peripheral layer. This peripheral tissue shows a differentiation into three regions (see fig. 1 A) :—

(1) *A medullary layer* surrounding the central cavity and made up of very loosely interweaving filaments ; these filaments are branched characteristically at a wide angle, and make up a very loose tangled mass. Their component cells are extremely narrow with mucilaginous walls and very small cell lumina.

(2) These branching filaments turn out towards the periphery and form parallel chains of cells making up the second or '*cortical layer*'. In this region the chains are branched, often in a corymbose manner, and the cells composing them are wider than those in the medullary layer and become progressively shorter as the surface is approached ; each cell contains several irregular deeply staining plastids and a very small nucleus.

(3) Each of the cortical chains of cells terminates in a larger rounded cell, with more scanty contents ; the adjacent cells of this layer adhere laterally and form a continuous '*epidermis*'. This layer appears to be quite homogeneous, and there is no differentiation into large colourless and narrow assimilating cells as in *Scinaia* (Svedelius, 1915). Narrow lateral branches arise in the cortical layer and push up between the epidermal cells but their tips appear to enlarge and add to the cells of the epidermal layer (see below). With increasing age the epidermal cells lose their contents, and a second cell is cut off from below each of them ; a ' cuticle ' is thus formed consisting largely of the compressed remains of two or three layers of epidermal cells. This process seems to be hastened by the presence of the numerous small epiphytes which are frequently found on the surface.

The construction is evidently of the fountain type (Oltmanns, 1923). Growth would appear to be apical, but there is no apical depression filled with undifferentiated filaments as there is in *Scinaia* and *Galaxaura* ; neither does it appear

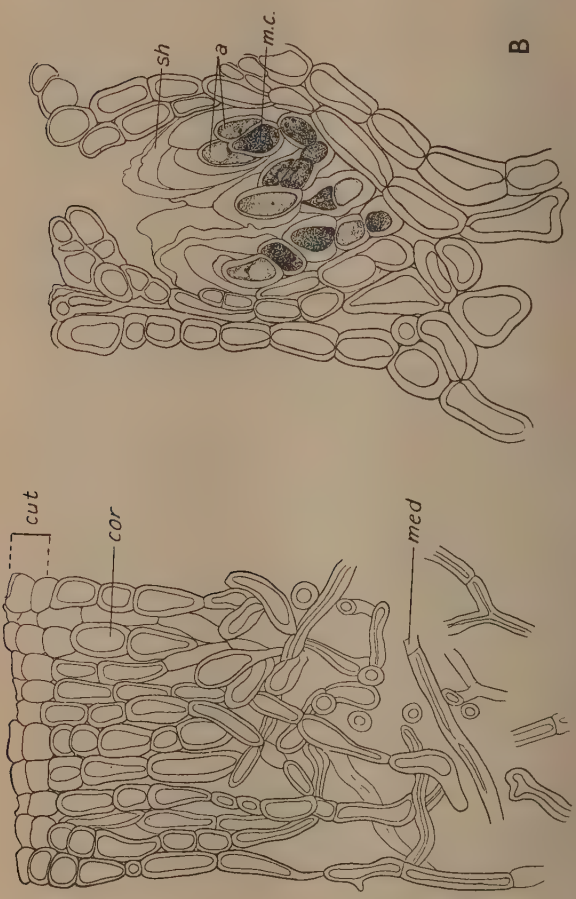

Fig. 1. Parts of V.S. through margin of thallus, (A) showing vegetative structure, (B) showing male cavity. *cut.* = 'cuticle' of crushed epidermal cells ; *cor.* = cortex ; *med.* = medullary filaments ; *a.* = antheridium ; *m.c.* = antheridial mother cell ; *sh.* = empty antheridial sheaths. × 1250.

to be strictly localized as in those genera. In the very young plant (1–2 mm. long) the whole of the rounded tip is occupied by narrow branching filaments running perpendicularly to the surface, and terminating in slightly swollen

rounded cells. Even at this early stage the centre of the plant is hollow, and is surrounded by a 'medulla' of loose branching filaments. As the plant increases in size, the terminal or 'epidermal' cells over the tip become enlarged, but never fit closely against their neighbours; numerous branches arise from the filaments in the inner cortical region, and their long narrow terminal cells push up between those of the cortical filaments, finally expanding to form enlarged cells similar to those of the 'epidermis'. In older regions all the epidermal cells cohere more closely and are somewhat compressed radially; occasional branches push up between them, but these are very rare in older parts.

It seems, therefore, that growth of the plant, at any rate in the later stages, is effected by lateral branches from cells in the cortical region, which push up to the surface and intercalate new epidermal cells between those already existing. So far as is known, this method of growth is unique amongst the red algae, but it is suggested by the process in other genera of the fountain type. In *Nemalion* and *Furcellaria*, the filaments of the central strand grow by means of apical cells at their tips; in *Furcellaria* especially this segmentation is very regular, and segments are cut off laterally from the apical cells. In *Scinaia*, however, growth seems to take place both by dichotomy of the apical cells of the filaments and also by later upgrowth of lateral branches. This leads on to the condition described here for *Chaetangium saccatum*, where segmentation of apical cells has not been seen, but growth seems to be entirely restricted to these lateral branches which insinuate themselves between the cortical filaments already existing.

Male Plants.

Male plants seem to occur at all seasons of the year, for some were found in each of the samples received, and all those examined showed ripe spermatia. The male plants are about the same size as the female and exactly like them in appearance; it is interesting to note, however, that of a batch of plants selected as the largest ever seen, all proved to be male.

The male reproductive cells are produced in small depressions of a conceptacle-like nature, recalling in some measure the condition shown in Schmitz's figure of *Galaxaura* (1897), and differing from *Scinaia* where they are borne superficially. These depressions can first be recognized about half a centimetre from the apex, and after a distance of one centimetre they are mature and are liberating spermatia. In their development, a branch arises low down in the cortical region and grows up towards the surface as do the vegetative

branches; here, however, the branch never reaches the surface, but at a level of three or four cells from it the terminal cell becomes enlarged and flask-shaped. This flask-shaped cell is the antheridial mother cell, and from it are cut off two or three antheridia (for details see later). These reach maturity while the cavity is quite small, and apparently before there is any well-marked opening to the exterior. Meanwhile, branching occurs by the outgrowth of any of the chain of cells immediately below the antheridial mother cell (fig. 2 *a*); from these a little clump of filaments grows up into the cavity, often accompanied by branches from neighbouring cortical filaments. The terminal cell of each of these branches becomes an antheridial mother cell, so that the floor and often the sides of the cavity are lined with these swollen cells, generally without any intermixture of sterile filaments (fig. 1 B). During this development of antheridial mother cells, the cortical chains surrounding them become pushed apart, so that a flask-shaped cavity is formed with a very narrow opening to the exterior. The size of the cavities varies very much; they may contain only two or three mother cells and are then only about 12–15 μ in diameter and about 20 μ in depth. When old, however, they are generally larger than this, and may measure as much as 25 μ in diameter and 40 μ in depth; the narrow aperture often becomes considerably wider as the cavity expands (fig. 1 B).

Development of Antheridia and Spermatia.

The antheridial mother cell is always terminal, and contains a single small nucleus and several irregular plastids aggregated near the base. When an antheridium is about to be formed, the mother cell elongates and becomes flask-shaped; a very thin oblique wall then appears, cutting off the upper narrow part of the mother cell from its wider base (fig. 2 *d*). By comparison with other Florideae, it seems probable that this wall grows in from the periphery, but owing to the very small size of the cells it has not been possible to ascertain this directly. This view is supported, however, by the fact that a pit connection is visible between the two cells, and this generally occupies the centre of the dividing wall (fig. 2 *h*, *i*). However this wall is formed, it is quite clearly a wide disc-like structure, and the antheridium and mother cell each have in consequence a flat surface next each other. The antheridium thus cut off increases very much in size, becoming roughly ovoid, with the side adjoining the mother cell still flattened, and a pointed end (fig. 2 *e*, *g*). Its wall becomes thicker and gelatinous; the pit connection with the

mother cell remains evident for some time, but finally disappears, leaving the antheridium very loosely attached near its pointed base (fig. 2 *i*, on right).

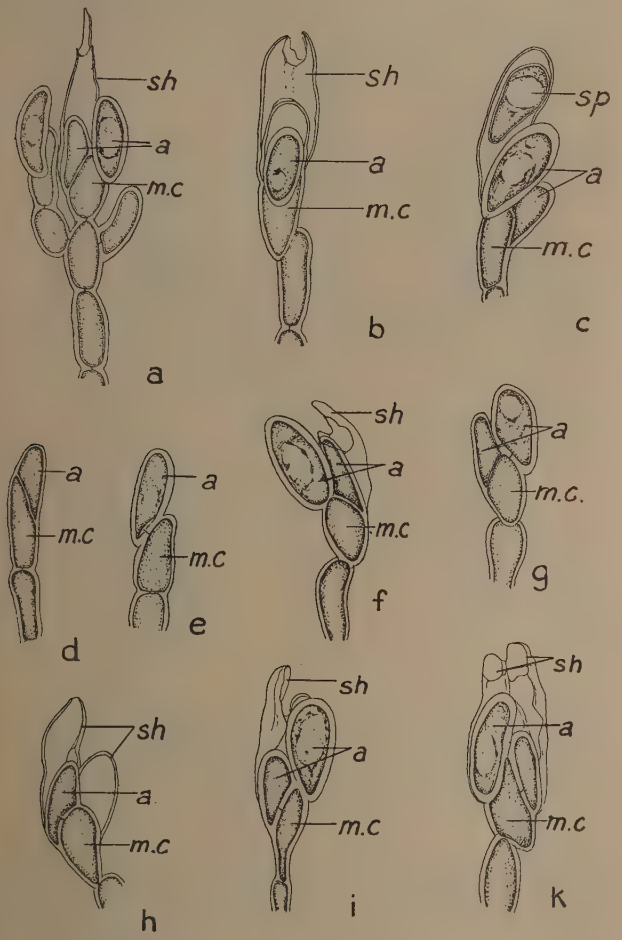

Fig. 2. *a–k*. Cortical branches from male plant showing stages in development of antheridia from antheridial mother cells. (From hand-preparations crushed and mounted in glycerine; not stained for nuclei.) *a.*=antheridium; *m.c.*=antheridial mother cell; *sh.*=empty antheridial sheath. × 1750.

Before the wall is formed cutting off the antheridium, the nucleus of the mother cell divides, one daughter nucleus remaining in the centre of the mother cell and the other passing up into the upper part; the oblique wall forms just below this upper nucleus (fig. 3 *a*). The nuclei at this stage are very small (·3–·4 μ in diameter), and it has been impossible to obtain any differentiation or stages in mitosis. The

Fig. 3. *a–d.* Stages in development of antheridium. ×2,500.
a, antheridium (on right) just cut off from mother cell.
b, antheridium (on right) showing pit connection with mother cell.
c, antheridium (on left) with nucleus showing ' Körnchen '.
d, on left—antheridium with nucleus in ' Körnchen ' stage; on right—mature antheridium showing nucleus and large vacuole.

antheridium when first cut off has finely granular homogeneous contents, and the very small nucleus passes to the centre; no signs of a plastid entering the antheridium have ever been observed. The nucleus then enlarges and resolves itself into a number of small granules, of which from six to eight can be counted (fig. 3 *d*, on left). This stage is of short duration; very soon several small vacuoles appear in the surrounding cytoplasm (fig. 3 *c*, on left) and coalesce to form one large

vacuole. This vacuole is generally formed above the nucleus, i.e. towards the apex of the antheridium; antheridia can, however, be found where the nucleus is apical and the vacuole below it, a position which is more usual for the antheridia of the Florideae. Meanwhile, the nucleus has become compact and homogeneous again, and applies itself closely to the vacuole. After this stage, it seems impossible to obtain any differentiation of the nucleus; at the time of liberation of the spermatium it is a rather ragged body pressed against the vacuole, and presenting signs of disintegration, while in the apical part of the antheridium and especially round the vacuole are numerous irregular granules which give the reactions of chromatin and seem to be nuclear in origin (fig. 3 *d*, on right).

While in this condition the spermatium is set free by the splitting of the antheridial wall at the apex. The wall, which up to this stage has been thick and gelatinous, stretches out and becomes thinner (fig. 2 *c*); its tip, by this means, reaches up to the opening of the male cavity, though it apparently never actually protrudes. The spermatium is probably liberated immediately below the opening of the cavity. This applies to young cavities where there are few mother cells liberating spermatia; in older parts where the cavities have become larger, the spermatia seem to be liberated into the upper part of the cavity, and find their way out through the now widened opening. The spermatium when liberated is an ovoid body with a pointed end and with a large vacuole slightly above the centre at its broadest part; it is fairly large, measuring about 7μ in length by 3μ in width (at the broadest central part). There has been some discussion whether the spermatium in the Florideae has a wall at the time of liberation; the free spermatia seen adhering round the openings of the male cavities in *Chaetangium* do appear to be surrounded by very thin walls, and in a few (fig. 2 *c*) it has been thought that this could be seen before liberation from the antheridium. Until fresh material can be examined, however, it is not possible to ascertain this with certainty.

After liberation of the spermatium, the antheridial wall is left behind as a thin and delicate sheath, with a hole (fig. 2 *a*, *b*, *k*) or an irregular split (fig. 2 *f*, *i*) where the spermatium has escaped. While the first antheridium is developing, a second primary one is forming. The mother cell elongates at its apex, and grows out into a narrow upper part, along the side of which lies the first antheridium; an oblique wall then cuts off the second antheridium on the opposite side of the mother cell (fig. 2 *g*). Although sometimes undoubtedly only two primary antheridia are formed, very often three are cut off from each mother cell, arising at regular intervals

round the sides. These always mature and shed their spermatia in strict succession. Fig. 4 is drawn at three different foci and shows a mother cell bearing three antheridia; the oldest of these (seen in *a*) is mature, while the youngest (in *b*) has only just been cut off from the mother cell.

Secondary antheridia are apparently always formed, and develop by the upgrowth of the mother cell through the sheaths of the empty primary ones. They are cut off by the same very characteristic oblique walls, and develop exactly as did the primary ones. The whole process of development is strictly regular, the first secondary antheridium growing up at about the time when the third primary one is mature. From the number of empty sheaths attached to a mother cell,

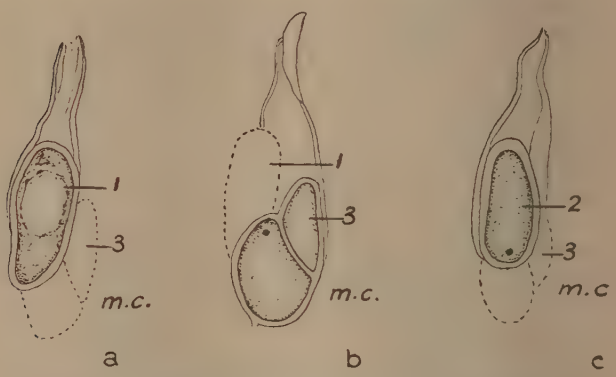

Fig. 4. Antheridial mother cell drawn at three different foci, to show three antheridia. ×2500.

a, at high focus, showing oldest antheridium (1).
b, at mid-focus, showing youngest antheridium (3).
c, at low focus, showing antheridium (2).

it seems probable that tertiary antheridia may be of frequent occurrence; this, however, is difficult to ascertain, as the sheaths are very thin and delicate, and are already four or six to each mother cell after liberation of primary and secondary spermatia. In microtomed preparations, where the mother cells and antheridia are in position around the base of the male cavities, it is impossible to make out the relations of walls and sheaths; these can be elucidated only by means of hand-sections which have been carefully crushed so as to isolate separate groups of male branches out of their cavities.

Position and Development of Antheridia in the Nemalionales.

Many of the simpler Nemalionales are monoecious, the antheridia and carpogonial branches being borne either on the same or on neighbouring tufts of assimilating filaments. This condition is found in *Nemalion multifidum* and in *Batrachospermum* ; it also occurs amongst more highly organised genera such as *Liagora* and *Scinaia*, and is found in *Bonnemaisonia asparagoides* (Svedelius, 1933), where male and female branches are often arranged in distinct zones. The dioecious condition, on the other hand, is found in many of the ' higher ' types, e.g. in *Asparagopsis armata* (Svedelius, 1933), in *Galaxaura*, and in *Chaetangium saccatum*, though not exclusively in these, since *Helminthora* amongst the simpler forms is also dioecious (Kylin, 1928).

Little is known of the external appearance or duration of the male plant in the dioecious species. In *Asparagopsis armata* the male plants resemble the female, but are much scarcer ; both male and female branch systems replace vegetative ' long shoots '. In the male plant nearly all the long shoots are replaced by male branches, and Svedelius considers that these are probably ephemeral, and are shed after liberation of the spermatia. In *Galaxaura* the male plants are similar to the female, but nothing is known as to their duration. The male plants of *Chaetangium saccatum* also resemble the female ; they occur at all seasons of the year, but do not seem to be short-lived, though after liberation of the spermatia the ragged surface soon becomes infested with epiphytes, and it is unlikely that the plants ever resume the vegetative condition.

In general, as first pointed out by Thuret (1855) the antheridia in the Florideae are developed in a position corresponding to that of the carpogonial branches. In *Nemalion*, *Batrachospermum*, and *Helminthora* both occur at the periphery of the tufts of assimilating filaments ; in *Bonnemaisonia asparagoides* and *Asparagopsis armata* male and female branches replace long shoots, and in *Chaetangium* and *Galaxaura* they are found lining flask-shaped cavities. *Scinaia*, however, is an exception, for there the antheridia are borne superficially, and the carpogonial branch and cystocarp sunken in the thallus tissue.

In the simpler members (*Nemalion*, *Batrachospermum*) the antheridial mother cells may be intercalary or terminal, and any of the three or four cells terminating a vegetative branch may bear antheridia ; in these genera the mother cells contain plastids and are scarcely to be distinguished from ordinary vegetative cells. In *Helminthora*, however, the antheridia are restricted to the terminal cells of the assimilating filaments,

and in all the ' higher ' genera the mother cells are terminal, whether terminating short lateral branches of a male shoot as in *Asparagopsis* and *Bonnemaisonia*, cortical branches at the surface as in *Scinaia*, or branches lining a cavity as in *Galaxaura* and *Chaetangium*. Svedelius does not mention the occurrence of plastids in the mother cells in the genera he describes ; in *Chaetangium saccatum*, however, several irregular plastids are present at the base of the mother cell.

Antheridia are developed in a lateral or sub-terminal position on the mother cell. In *Batrachospermum* and *Nemalion* they are formed laterally in no regular order or number. Cleland (1919) records four or five from a mother cell in *Nemalion multifidum*, but figures of *Batrachospermum* and *Helminthora* show only two. In most other genera the number varies from two to three, and the development is more regular. Svedelius describes and figures two antheridia in *Asparagopsis* and *Bonnemaisonia* (though Kylin, 1916 (ii), found that there were often three in the latter), produced one after the other at either side of the apex. A similar condition is seen in *Scinaia* and in *Chaetangium saccatum*, where two or three antheridia are produced in regular succession in a sub-terminal position. In the last two genera secondary antheridia are of common occurrence (and in *Chaetangium* possibly tertiary) ; secondary antheridia have also been recorded for *Nemalion multifidum* (Cleland, 1919), while Kurssanow (1909) figured as many as six antheridial sheaths one inside the other in *Nemalion lubricum*. In *Asparagopsis* and *Bonnemaisonia*, however, Svedelius failed to find any signs of secondary antheridia.

Comparison with other Florideae.

In this study of the male plants of *Chaetangium saccatum*, two points have emerged which seem to be of interest for the Florideae as a whole. One of these is the method by which the antheridium is cut off from its mother cell. In *Chaetangium saccatum*, as described above, the wall cutting off the antheridium is an oblique one, probably growing in from the margins, and with a pit connection left in the middle ; the whole upper part of the mother cell is cut off by this wide wall. This resembles the condition figured by several other workers, e.g. by Svedelius for *Delesseria sanguinea* (1912). A rather different process is described, however, for many of the higher Florideae by Grubb (1925). The antheridia develop as protuberances of the mother cell until about equal in length to it : ' the contents are abstricted from those below by a ring-like ingrowth of the .... mother cell wall '. From the figures given by this author, however, the process would appear to

be of two kinds: that shown for *Furcellaria* where a wide ingrowing wall meets and leaves a pit connection in the middle, and that figured for many other forms (e.g. *Nitophyllum Hilliae*) where the contents of the antheridium are constricted off by narrowing of the base, so that the antheridium is eventually borne on a narrow neck and resembles a basidiospore on its sterigma. The process seen in *Chaetangium* is very different from this last, and comparison with related forms has been sought. There is no clear account of the manner of cutting off of antheridia in other Nemalionales; figures of *Nemalion multifidum*, however (especially those of Wolfe, 1904), show antheridia borne laterally on the mother cell and adjoining it by a broad base, in the centre of which is a pit connection. Observations I have made on *Nemalion* confirm this, and the process seems to be very similar to that described here for *Chaetangium*. A similar sequence of events takes place in *Batrachospermum*. In *Scinaia*, *Bonnemaisonia*, and *Asparagopsis*, however, although no description is given, Svedelius's figures indicate that the antheridia are constricted off by narrowing of the basal region. It is probable that further investigation will reveal two main types of antheridial development in the Florideae: (i) that with a wide dividing wall, probably ingrowing—such is described here for *Chaetangium saccatum*, is found also in *Nemalion* and *Batrachospermum*, and is suggested in the higher Florideae by Grubb's figures of *Furcellaria* and Svedelius's *Delesseria sanguinea*; (ii) that where the antheridia are constricted from the mother cell by narrowing or 'pulling out' of the basal region, as figured by Grubb for many of the higher Florideae and suggested by Svedelius's figures of *Scinaia*, *Bonnemaisonia*, and *Asparagopsis*. These two types are impartially distributed amongst 'higher' and 'lower' Florideae, though perhaps constriction is more usual in higher types. The nature of the process is possibly to be correlated in some way with the shape of the antheridium and its position on the mother cell.

Another point of interest raised by this study of *Chaetangium saccatum* is the condition of the nucleus in the developing spermatium. Mitosis of the antheridial mother cell nucleus has been described by many workers; some maintain that the daughter nucleus passing into the young antheridium remains in prophase, but most are now agreed that it resumes a resting condition. Soon, however, the nucleus appears to lose its nuclear membrane and shows a differentiation into granules or 'Körnchen' as the antheridium matures: the ripe spermatium contains generally a large vacuole, and apically a nucleus very distinctly in the prophase condition.

In *Chaetangium* the nuclear phenomena are very peculiar. The antheridial nucleus can be recognised at an early stage as an extremely small homogeneous body ; after this there is some indication of a prophase stage in the enlargement of the nucleus and its differentiation into rounded granules. This is, however, of very short duration, and the nucleus of the ripe spermatium is a ragged body adpressed to the vacuole, and showing signs of degeneration in the irregular granules of chromatic material scattered around the vacuole. This condition does not seem to be due to bad fixation, for the same appearance is produced with each of the fixatives used, and the preservation of the rest of the contents and the very delicate cell walls is quite good ; it seems possible that the degenerate appearance of the nucleus is a real one, and the suggestion is put forward that the spermatia here are non-functional, and that their nuclei are degenerating. In this connection it may be mentioned that so far no spermatia have been seen in association with the trichogynes in the female plants.

In conclusion, I should like to thank Miss E. L. Stephens for her constant trouble in collecting, fixing, and despatching material, and for useful information concerning the plant in its natural habitat : I am also indebted to Mr. E. J. Steer of Sea Point for the photograph reproduced in Pl. **10**. My grateful thanks are due to Dr. E. M. Delf and to Dr. V. M. Grubb for much encouragement and helpful criticism during the course of this work.

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Photo by E. J. Steer. John Bale Sons & Danielsson Ltd London

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EXPLANATION OF PLATE 10.

Chaetangium saccatum—plants *in situ*. ×½.

Dr. E. M. Delf commented on the peculiar habit of the plant and on the large numbers which had been examined in order to establish the results mentioned. She also drew attention to the peculiar manner in which the outer surface becomes covered by the collapsed walls of successively formed cell layers—a method rare, if not unique, amongst marine algae.

In commenting on Miss Martin's paper, Dr. V. M. Grubb remarked on the great difficulty of handling these tougher marine algae and of interpreting the very minute structures present. She commented on the peculiar constitution of the outer layers of the thallus, and asked whether it were possible to distinguish any 'cuticle' covering these outer dead layers of cells such as is present in other marine algae. Attention was also drawn to the vacuolate and ragged appearance of the spermatial nucleus, a condition which so far appears to be unique among red algae, and it was asked whether there were any signs of degeneration in the female organs to correspond with this apparent degeneration in the male.

In reply to Dr. Grubb, Miss Martin said that it was possible to distinguish a very thin 'cuticle' covering the outer layer of cells. So far as was known, there were no signs of degeneration in the female organs; on the contrary, well-developed trichogynes were present, and some of these had been seen to reach the outer surface.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—No. 17. The vertical distribution and movements of the plankton in Lakes Rudolf, Naivasha, Edward, and Bunyoni. By Dr. E. B. WORTHINGTON and Miss C. K. RICARDO. [Abstract.]

A FEW years ago the Cambridge Expedition investigated the vertical distribution of the plankton in some of the East African Lakes and a few of the more interesting results are given here. The material was all collected by means of vertical hauls with Nansen type closing nets of fine and coarse mesh.

Lake Rudolf is the largest of the lakes with a depth of about 48 metres, and has very high values for temperature, pH, and alkalinity. The most striking species in the fine net hauls is a small ciliate, which occurred in enormous numbers and which frequently contained symbiotic vorticellids. It was remarkable to find that the diurnal migration of the dominant species of the macroplankton, *Diaptomus banforanus*, appeared to be in the reverse direction from the normal as the animals were near the surface in the daytime and in the deeper water in the night. The other two important species in the lake, however, showed migrations in the normal direction.

Lake Naivasha is very shallow with a depth of 15 metres and has lower values for temperature, pH, and alkalinity. The fine-net hauls in this lake showed that all the species were at a lower level in the lake in the day than at night, and that there appeared to be a diurnal migration of non-motile as well as motile forms. The temperature curve showed a reverse gradient at 6 a.m., which suggests that there was a complete circulation of the water which carried the organisms passively down to the deeper water and back to the surface. The macroplankton showed normal migrations, but the animals were caught in far greater numbers by night than by day, and the form of the histograms suggests that most of the individuals were very near the bottom in the daytime in the region that was not fished by the net.

Lake Edward was the deepest of the lakes with a depth of 90 metres and had a thermocline developed between 40 and 60 metres. Hauls were made to investigate the effect of the thermocline, and these showed that there was little life below 60 metres.

In Lake Bunyoni, the phytoplankton was very scarce in the fine net hauls, but the abundance of the zooplankton and the rise in pH at mid-day near the surface suggests that there must have been plant material present. The diaptomids of the macroplankton showed indications of being, as in Lake Rudolf, at a higher level in the day than at night.

The main errors in this work are the lack of uniformity in the horizontal distribution of the species, and the fact that the bottom two metres were not fished by the net.

These results are given only as data in the hope that they may be of use in building up the ultimate picture of plankton distribution and behaviour.

Dr. G. P. Bidder enquired whether dredgings of the actual bottom threw any light on the deficiency of plankton in the deepest hauls of the net.

Mr. A. G. Lowndes, who had been responsible for the taxonomic work of the Entomostraca, expressed his interest and great appreciation of the paper. He thought, however, that insufficient attention had been given to the Ostracods. He agreed very fully with Miss Ricardo's statement that the bottom two metres in making these trawls was of the greatest importance. It was in this region that the Harpacticids and most of the Ostracods occurred. These were highly predaceous, and probably played a large part in driving the other Entomostraca into the more open waters.

With regard to the question of hydrogen-ion-concentration and its importance, Mr. Lowndes reminded members that some years ago this question had received considerable attention, Professor Alphonse Labbé even maintaining that it was possible to convert one species into another simply by a gradual change in pH. Surely this theory had been exploded years ago by Dr. Robert Gurney and himself.

Mr. E. R. Gunther also made some comments.

Miss Ricardo replied that, with regard to the sizes of the day and night catches, Russell at Plymouth has shown that by fishing with special dredges in the bottom two metres the difference in the size of the catches is less marked, but that even then larger numbers are generally taken in the night hauls. She agreed that the region near the bottom was extremely important in work of this kind, and that it should be investigated in detail in future expeditions.

Some interesting points in the anatomy of the freshwater dolphin Lipotes and its allies. By Mr. M. A. C. Hinton, F.R.S.

Lipotes vexillifer, described by Miller in 1918, is a remarkable freshwater dolphin, belonging to the family Platanistidae, inhabiting the Tung Ting Lake about 600 miles up the Yangtze River, China. The original material was incomplete, consisting of the skull and cervical vertebrae of an adult male, which in the flesh had a length of about 8 feet, accompanied by a photograph of the animal and an external description drawn up by the collector, Mr. Charles M. Hoy. As the result of a very careful comparison Miller concluded that this creature would have to be placed in a special genus, *Lipotes*,

and that it had closer affinities with the South American genus, *Inia*, than with any other—a view which was accepted by Winge.

In May 1922 the British Museum received a female *Lipotes*, measuring from tip of snout to the notch of the flukes 6 feet 10 inches in length, frozen in ice, as a gift from Dr. Skinner of Hankow. It was accompanied by a male Finless Porpoise, *Neomeris phocaenoides*, from the same lake similarly preserved in ice. Plaster casts of these two specimens were made in the Museum and are now exhibited in the Whale Hall. After the casts had been made the specimens were dissected by Mr. W. P. Pycraft and the author, Mr. Pycraft being responsible chiefly for the viscera and the author for the remainder of the animals. At that time we had no means in the Museum of injecting such large specimens and we had to content ourselves with groping through the coarse anatomy as best we could. A complete photographic record of the work was made as it proceeded, and many preparations were preserved. A preliminary note on the results of our researches was published in 1922 (Hinton and Pycraft), but the continuous inflow of new work has prevented us from publishing the complete account which we then hoped to give.

Lipotes is a member of a small and primitive group of freshwater cetaceans, which contains the living genera *Platanista*, *Inia*, and *Pontoporia* (=*Stenodelphis*), and several fossil genera as well. All the members of the group are long-beaked forms. The eyes are very small in *Lipotes*, set in deep fleshy orbits and weakly functional; in *Platanista* they are reduced to minute vestiges devoid of a crystalline lens.

Lipotes is remarkable for its excessive asymmetry, the right side being much over-developed. This is readily apparent in the front view of the animal, the face being so twisted that *Lipotes* is by far the ugliest of all the cetaceans. The blow-hole is not a transverse crescent, as in *Inia*, *Pontoporia*, and most other dolphins; it is longitudinal, somewhat rectangular in form, and pushed over to the left side. In *Platanista* it is a median longitudinal slit, so that as regards form and direction the blow-hole of *Lipotes* is intermediate between the normal condition seen in *Pontoporia* and the highly specialized one seen in *Platanista*. Striking evidence of the asymmetry is seen in the anatomy of the spiracular sac, but it runs all through the creature; thus in the caudal peduncle prolongations of the neural spines of the vertebrae would come out on the left side of the dorsal surface and not in the middle line. The whole body seems to have twisted round inside its jacket, so to speak.

The spiracular sac of *Lipotes* is of extreme interest. As in ordinary dolphins (e.g. *Lagenorhynchus*) it is provided with

paired valves, a deep set and a superficial set, and from its sides diverticula or air pouches pass outwards into the subcutaneous tissue or between the layers of the *dilator naris* muscle. The valves and pouches of the right side in *Lipotes* attain an enormous development; but the pouches on the left side are small and rudimentary. The superficial valves are controlled by a pair of special 'bones', which if not truly ossified are formed of very dense fibrous tissue, and which are worked by special protracting and retracting muscles. The inner borders of these 'bones' pass into the connective tissue surrounding the blow-hole, but their outer borders are free and a great deal of movement is possible. When retracted the 'bones' serve to close the blow-hole tightly forming a sort of lock to the whole apparatus. The air pouches lie below the 'bones', which are deeply pitted on the ventral surface for their reception. On the right side, however, the pouch sends a prolongation beyond the free border of the 'bone', and this prolongation passes upwards and over the dorsal surface of the 'bone', immediately below the integument.

Since the work was done on *Lipotes* the author has had an opportunity of dissecting *Pontoporia*. In that genus, too, essentially the same structure of the spiracular sac occurs, the valves, pouches, 'bones' with special protracting and retracting muscles, being all as in *Lipotes*, but far less developed and without the marked asymmetry of the latter.

It may be suggested that in these spiracular 'bones' of *Lipotes* and *Pontoporia* we see the beginnings of the well-known maxillary crests of the skull of *Platanista*. The latter may have arisen as part of the spiracular apparatus which later, attaining a much larger lateral development, united with the maxillaries and lost their mobility and therefore their primitive function of closing the sac. It is to be hoped that some *Platanista* material in the flesh will be obtained to enable further dissections to be made with this possibility in mind.

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Sir Sidney Harmer congratulated Mr. Hinton on the interest of his communication. He and Mr. Pycraft had made the best possible use of this rare Dolphin by studying its anatomy. If it had not been for their enterprise the specimen would have been used merely for keeping a record of the external characters of *Lipotes* and as material for the preparation of a skeleton.

The following papers were read in title :—

'South African species of *Riella*, including an account of the developmental morphology of two of the species.' By G. WIGGLESWORTH. (Communicated by Professor F. E. WEISS, F.R.S., F.L.S.)

'*Epimedium* and *Vancouveria*: a monograph.' By W. T. STEARN.

'Studies in the Arabian Orthoptera.—I. Descriptions of new genera, species, and subspecies.' By Dr. B. P. UVAROV. (Communicated by Dr. HUGH SCOTT, F.L.S.)

The President announced that his Presidential Address, to be given at the Anniversary Meeting on 28 May 1936, will deal with 'The origin of insects'.

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